

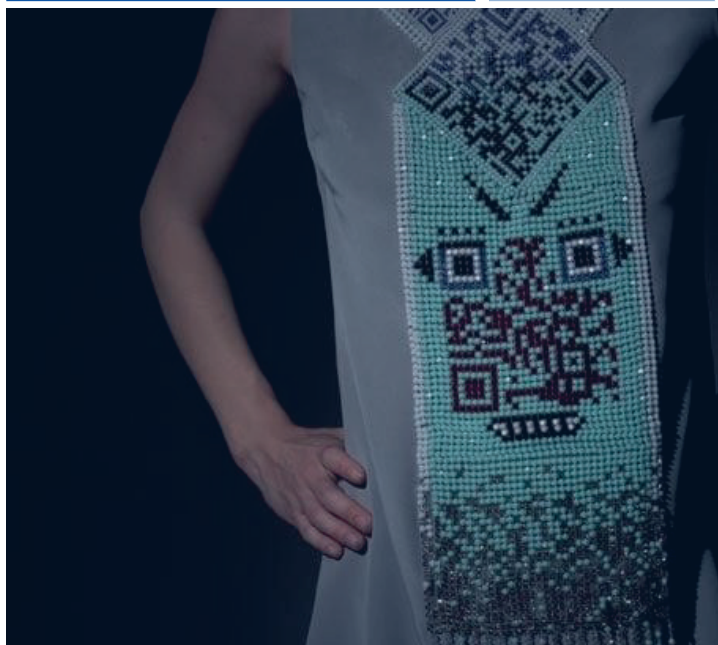


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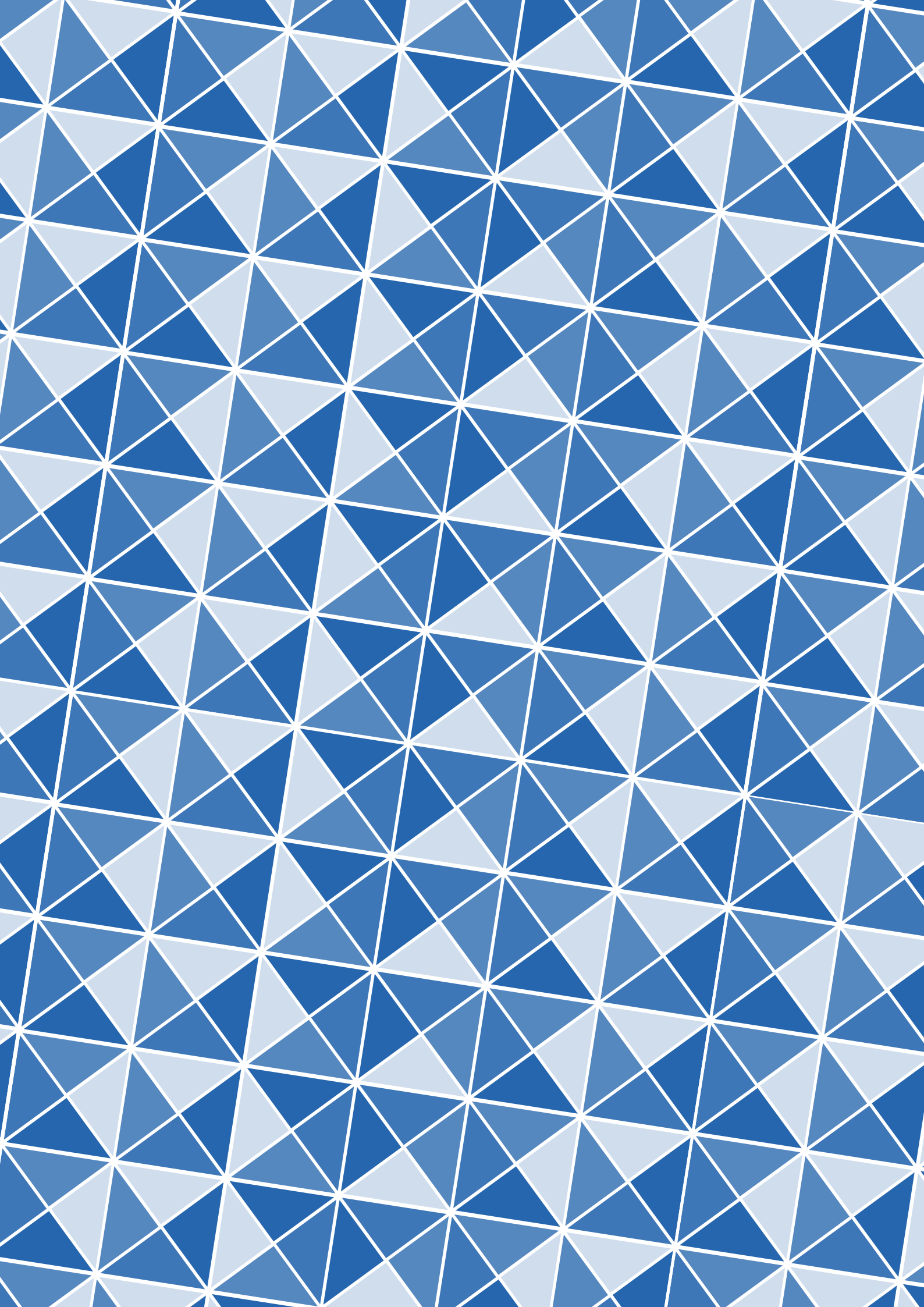
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Analysis of packaging design its colour coding and labelling of contained sugar in dairy and cereal products

ABSTRACT

The purpose of developing the colour coding system is to create better awareness and help consumers monitor and understand the sugar content of foods. Our research focused on food products (dairy products and cereal products on the Slovenian market) that contain so-called hidden sugars, as these can cause many health risks. The aim of the study was to raise awareness of the sugar content in dairy products and cereals through a packaging design with a uniform labelling and coding system. During the process of this research, few answers were provided to the following questions: How can a labelling system be designed to be clear and impartial, what is the hierarchy and layout of food information on packaging, and how can the system be coherently integrated with existing packaging? The impact of the information design on the consumer in the food packaging industry, which helps in further execution, was analysed. Based on the research, variants of a multi-colour labelling system were created, differing in primary information graphics, colour, placement and formats. The packaging for an imaginary brand and the placement of the code system were designed. Finally, the packaging design was implemented in the 3D models for each food group. The result of this research is a collection of packaging models with a labelling system that informs consumers about sugar content, facilitates decision-making and helps them control their food intake. The colour-coded labels were applied to the packaging in a uniform and coherent manner, which can provide sufficient attention and information.

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Packaging design, dairy products, cereal products, sugar, labelling, labelling system

Introduction

People encounter sugar in ever greater quantities in our daily lives, as it is found in almost every packaged food. When defining sugar, it is important to know the difference because there is natural sugar, which is safe for health, and added or free sugar, which can affect the body in different ways. Sugar is added to foods for its myriad beneficial properties, but at the same time it can also quickly become over-added, leading to excessive consumption and damage to health. Therefore, it is important to pay attention to and inquire about the ingredients when buying and consuming

certain products. The excessive sugar content of many products is well known (carbonated drinks, ice cream, sweets, etc.), but some foods are often advertised as healthy or beneficial to health (yoghurt, milk or muesli). The latter products belong to the so-called hidden sugar products, of which there are more and more on the market today. As the name suggests, these sugars are quite hidden and their presence is almost unknown to the average consumer, as reported by the University of California, San Francisco (University of California San Francisco, 2023). Either the buyer does not pay attention to the declaration, does not notice it at all or does not understand it, as many unfamiliar

and professional terms are used to indicate the sugar content. Different types and formats of declaration labelling have been created to make the nutritional value of foods easier to understand. Although there are already some inconsistent versions of sugar content labelling on the world market, not all of them are effective.

In research by Scapin et al. (2020) and Jonas et al. (2019), several different labels to which consumers responded differently were analysed. For better understanding and to encourage the choice of foods with lower sugar content, they were the most effective interpretive formats with the sugar content in grammes combined with colours, a statement about the high sugar content ("high in sugar") or the percentage of the daily value (the daily value is the same as the value that describes what percentage of the final value the food contributes in a per serving (U.S. Food & Drug Administration., 2023). Labels explaining high sugar text, warnings, health claims and a graphical representation of sugar content in teaspoons were slightly less effective than. Erickson and Slavin (2015) investigated how new sugar recommendations and guidelines with only 5% free sugars in total calories influenced consumer behaviour and labelling on the packaging of the same products. Scapin et al. (2020) investigated and found that formats that provide interpretation of sugar information, regardless of food category, but particularly those that indicate whether a product is high in sugar, are more helpful than numerical information alone in improving consumer understanding and encouraging lower sugar food choices.

So far, the uniform labelling system in Slovenia has been little explored and is not yet used on the market. In the European Union, it has not been possible to establish a uniform model or labelling format for nutritional profiling of foods due to the lack of uniform nutritional reports (chapters with recommendations on sugar intake), uniform food composition data and insufficient data on consumers' dietary habits (Eržen, 2014).

As mentioned, the lack of a clear definition of free and added sugars leads to inconsistencies and misinterpretations of the declarations by consumers, scientists and manufacturers. Some organisations use the term "added sugars", while others, such as the World Health Organization (WHO), use the term "free sugars" for the same purposes (World Health Organization, 2015). Furthermore, labelling claims that only define the total amount of all sugars and not the individual amount of added or natural sugars create uncertainty for consumers. Additional labelling issues also arise from the method used to measure sugar content, as nutritional analysis uses different chemical methods to measure the nutritional value of foods, such as quantitative analysis to determine the amount and chromatography to identify the sugar. Two different types of chromatography are used, namely gas chromatography and liquid chromatogra-

phy (HPLC). However, both are unable to distinguish whether the sugar in a food is naturally occurring or added by the manufacturer (Goldfein & Slavin, 2015). Consumers can find out the sugar content of a food themselves by looking at the ingredients, which are listed in descending order of quantity (Yeung, Goodfellow & Flanagan, 2015). Again, complications arise as consumer knowledge is often limited and many sugar terms are difficult to understand. The following table (Table 1) lists some common names for sugars in food ingredients.

Table 1

The most common types of sugars and the names under which they often appear (Zupančič, 2020)

| Type of the sugar | Other names |
|-------------------|--|
| glucose | dextrin, dextrose, rice syrup, maltose, barley malt |
| sucrose | crystallized fructose, fructose syrup, fruit sugar |
| fructose | beet sugar, cane sugar, demerara sugar, sugar, caramel, brown sugar, sugar cane juice, muscovado sugar |

By requiring clear sugar labelling for products such as dairy products and cereals, governments can help consumers make more informed choices. Therefore, clear and unique sugar labelling for mentioned products could be labelled with the amount of added sugar as well as the total amount of sugar. The aim of the study was to raise awareness of the sugar content in dairy products and cereals through packaging design and to design a uniform labelling system that can be used for many products.

Materials and methods

This research followed a systematic approach consisting of five steps carried out to analyse the sugar content in dairy and cereal products and then incorporate the results into 3D packaging placements. A novel colour labelling system was also developed for improved visual presentation. The individual steps of this research are described below:

1. Sampling and sugar content analysis of dairy and cereal products from the Slovenian market

The research involved two primary steps:

- a. sampling the dairy and cereal products available in the Slovenian market,
- b. analysing the sugar content in dairy and cereal products.

a) Sampling the dairy and cereal products available in the Slovenian market

The analysis included a comprehensive examination of dairy and cereal products available in the Slovenian market in total of 47 dairy product samples sourced from 12 different producers and 15 cereal product samples. The samples were carefully selected to include a diverse range of product types. For 5 food groups, several products were analysed in different stores as followed:

- cereal box-15 samples,
- yoghurt or milk bottle/bottle-10 samples,
- butter packet-12 samples,
- milk carton-10 samples,
- yoghurt container-15 samples.

b) Analysing the sugar content in dairy and cereal products

Using the samples that contained natural, fruit and protein yoghurts, the statistical functions of frequency distribution were used to determine the classes based on the increasing amounts of sugar in the foods. The classes enabled the use of logical colour coding in the further development of the scale, as we could assign a specific colour to a specific class, e.g., the lowest class with the lowest sugar content belongs to the blue colour, etc. In the product range, the minimum sugar content was 3.8 g and the maximum was 14.0 g. Table 2 below shows the distribution of the products in 5 consecutive classes with an interval of 2.5 g sugar. The class describes the range of sugar content in grammes and the frequency describes the number of products belonging to that class.

Table 2

Frequency distribution of the amounts of contained sugar and distribution into classes at analysed dairy and cereal products.

| Class | Frequency |
|-----------|-----------|
| 3.0-5.4 | 28 |
| 5.5-7.4 | 1 |
| 8.0-10.4 | 7 |
| 10.5-12.9 | 9 |
| 13.0-15.4 | 4 |

The levels or classes of sugar in food were created based on analyses of dairy and cereal products available on the Slovenian market. The sugar scale contains five classes ranging from the lowest to the highest sugar content (Table 3). In contrast to the middle three open intervals, the minimum and maximum classes have less than 3 g of sugar and more than 15.4 g of sugar, respectively.

Table 3

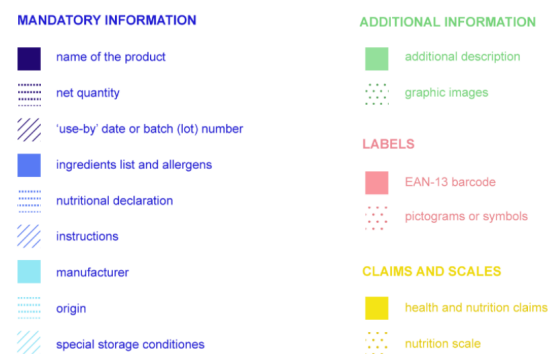
Ascending classes of amounts of sugar in grammes [g].

| Very low | Low | Medium | High | Very high |
|----------|-----------|------------|-------------|-----------|
| < 0.3 | 1.5 – 7.9 | 8.0 – 10.4 | 10.5 – 12.9 | > 15.4 |

2. The graphic analysis and the preparation of the layout and the hierarchy of information on the packaging for a specific food group

For each piece of information (classified into one of the 4 groups in the legend – Figure 1), each of the samples for that food group was analysed, its position noted and then counted and determined where on the packaging the information occurred most frequently, and then that option chosen for placement on the packaging. Each sample was meticulously documented, recording the product manufacturer, the product type and the corresponding amount of sugar contained. This approach ensures a robust and representative data set for the analysis of sugar content in these food categories.

Further in the research process, the scales were applied to the graphically designed food packaging, which was designed on the basis of the previously mentioned analyses. The packaging for each food group was analysed, focusing on the presence and placement of information in the legend (Figure 1).



» **Figure 1:** Legend of the data used in the analyses according to packaging and sugar content.

The first group of data is coloured blue on the analysis cards and includes the legally required information, such as product name, net quantity, best-before date or batch (lot) of the food if the best-before date is not indicated, list of ingredients followed by allergens if the product contains any (cereals, eggs, nuts...), nutritional value of the food, instructions (only if there is a possibility that the consumer will not be able to use the food properly without them), manufacturer, origin (only if the absence of information could mislead the consumer as to the true origin) and special storage conditions.

The second group of data is coloured green and represents additional information, such as additional description of the product, e.g., suggestions for preparing a dish, information about the production (e.g. natural and organic grown on a farm), a description of one of the ingredients (e.g. oatmeal and its influence on a healthy diet), contact of the producer, distributor, etc. The second option is represented by

green dots and includes graphic images such as the company logo, various illustrations and photos.

The third group is indicated by the pink colour used to represent the labels, namely the EAN-13 barcode and pictograms or symbols (mostly these are indications of the type of packaging material, the label suitable for contact with food and the placement of the packaging in a suitable place).

In the last or fourth yellow group are health and nutrition claims and various scales (e.g. Nutri-score).

3. Graphical analysis and comparison of the different types of the current labelling

A graphic analysis and comparison of the different types of labelling (symbols, colours, formats) on the Slovenian market and in other countries of the world followed. Based on this analysis, several versions of labels were created, differing in symbols, colours, formats and layout.

4. Creation of new sugar labelling system and packaging design

The created labelling systems were placed and designed on the designed packaging (labels) for an imaginary brand based on the previously conducted analysis.

5. Preparation of 3D packaging design model with new sugar labelling

Finally, a 3D model of the packaging was created to represent it more simply and realistically. For each food group (yoghurt, milk, butter, cereals) a packaging model was created with two versions of the labelling.

Results

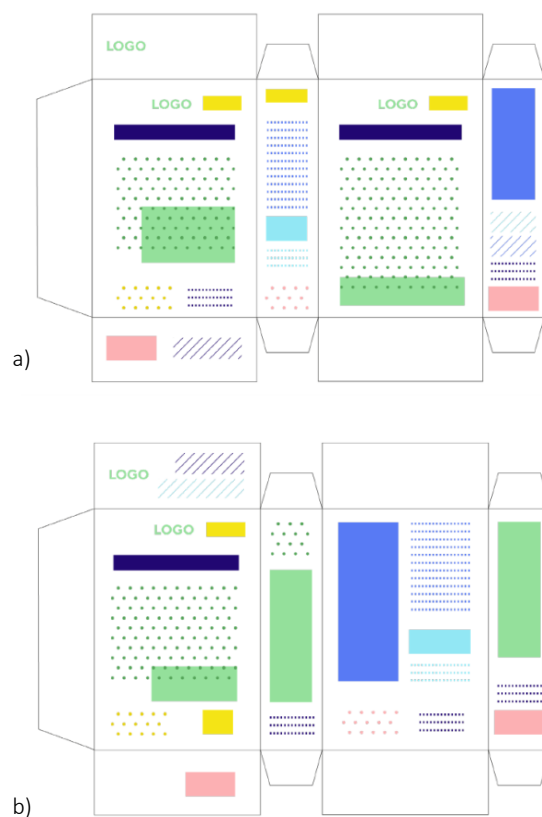
Results of the graphic analysis and the hierarchy of information on the packaging for a specific food group

A detailed analysis of dairy products was carried out to establish a scale corresponding to ascending sugar content. Using dairy samples, a frequency distribution was made to classify them according to ascending sugar content. These classifications facilitated the introduction of a coherent colour coding system, where specific colours were assigned to specific sugar content ranges. Subsequently, the scales derived from this analysis were applied to visually designed food packaging, focusing on the arrangement and inclusion of information. The packaging analysis included mandatory information, additional product details,

contact information, barcodes, symbols and health claims as described in the following chapters.

Packaging design for cereal box

An analysis of cereal boxes showed two versions most found in stores (Figure 2a and 2b). Both versions have a common main side with the logo and product name in the top third of the box and the nutritional information on the right-hand side. An alternative placement for the nutrition information, which is often interchanged with the nutrition label, is the bottom third of the package on the right or left side. In addition, the logo also appears on the top or lid of the packaging for both versions. The two versions differ mainly in the design of the ingredient list and the nutritional information.



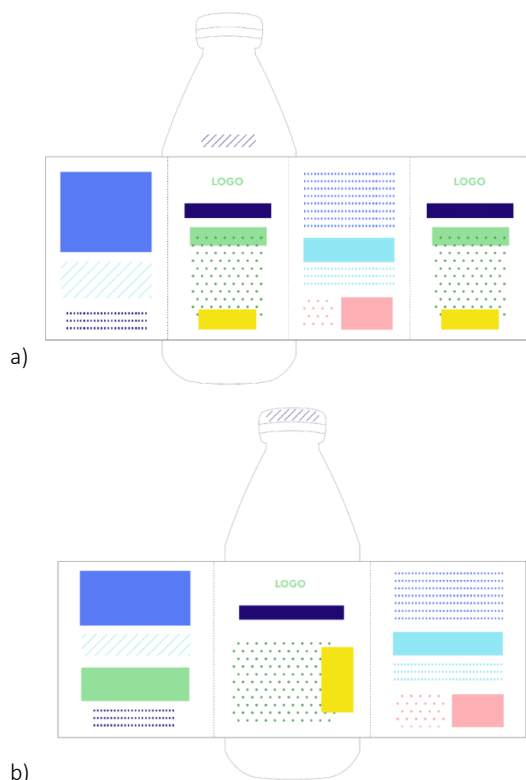
» **Figure 2:** Two different versions (a and b) of the analysis of information placement on cereal packaging (boxes).

The two versions differ mainly in the layout of the list of ingredients and nutritional values. One noticeable difference is that in the first version (a) the primary page is repeated exactly the same or with a similar graphic and additional information on the back. Consequently, the information on ingredients, nutritional values, instructions and manufacturer appear on the right and left sides. Because of the seemingly smaller surface area, these details are often close together, they can appear less clear and are more difficult to see. On the sides, this

information is usually accompanied by labels (EAN-13 and pictograms). The net quantity often appears on the first page and on one of the sides. In the second version (b), the primary page is not repeated, but the ingredients and other obligatory information are on the back. Additional descriptions and graphics appear on the sides because there is much less information and therefore, they are better suited for smaller spaces. In both cases, the barcode appears not only on one of the sides, but also on the bottom of the box. Also, the date of use can be found at the bottom in the first version (a), while in the second version (b) it is at the top together with the storage conditions. The latter is easier to see and the arrangement with the storage conditions makes sense, as the storage of the product can influence its usability.

Packaging design of bottle for milk or yogurt

As with the analysis of the boxes, the bottle labels could also be divided into the two most frequently found variants (Figure 3a and 3b).



» **Figure 3:** Two different versions (a and b) of the analysis of information placement on bottle for milk or yogurt.

The two versions differ mainly in the repetition of the primary side, namely that the label of the first version (a) is divided into three relatively equal parts, of which the primary side appears only once, while the label of the second version (b) is divided into 4 equal parts and the primary side is also repeated on the reverse side in the same image. The repetition could allow

faster recognition of the product on the shelf from different angles, as bottles and vials are often turned in random directions on the shelf, either by the customer or by the staff when stacking the products.

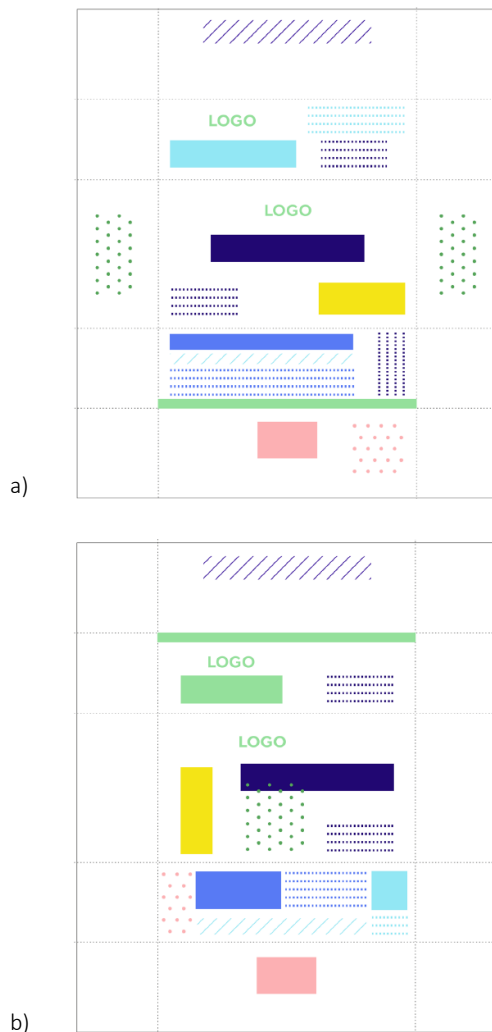
In the second version (b), there are two pages with most of the compulsory information between the two main pages. On one of the pages you will usually find the ingredients and the storage conditions, while on the opposite page you will find the nutritional value of the product as well as the manufacturer and the origin. This page also contains labels (EAN-13 and pictograms). In the first version (a), the data is arranged almost identically to the second (b), but the first version, by eliminating the primary page, allows a larger area of the page and thus its use for additional information. The best-before date for bottles appears either on the bottle itself or on the cap, whereas for bottles it usually appears only on the cap. The net fill quantity usually appears only once on the entire label for both versions.

Packaging design of butter

Just as with the bottle and the box, twelve samples (Slovenian and foreign producers) were used to identify two dominant versions (Figure 4a and 4b) and to design a standard packaging.

The primary sides are quite similar on both versions, as they both contain the logo and product name as well as the net fill quantity in the lower left or right corner. Nutrition or health claims appear less frequently on butter packaging than on muesli, yoghurt and milk, but when they do, they appear on the left-hand side or in the lower right-hand corner. Graphic images also appear on both versions, but to a much lesser extent than on other products, as the lid also has a relatively smaller surface area. The images appear directly to the left and right of the primary page on the first version (a) and directly on the primary page on the second version (b). The biggest difference is the placement of the mandatory information. In the first version (a) they are directly above and below the primary page, with manufacturer, origin and net quantity appearing most frequently above the page. Below the primary page are the ingredients, followed by the storage conditions, the nutritional value and the repeated net quantity. In contrast to the first version (b), most of the information (ingredients, nutritional value, storage conditions, manufacturer, origin and pictograms) is rather compressed on one of the pages (usually below the primary page). This makes the information appear less orderly, harder to understand and also harder to recognise due to the reduced font size. The page above the primary page contains a repetition of the logo, similar to the first version, which helps to recognise the product or brand from different angles. This page is often accompanied by an additional description and

the net quantity. For both versions, the barcode EAN-13 and the date of use appear at the bottom of the label.

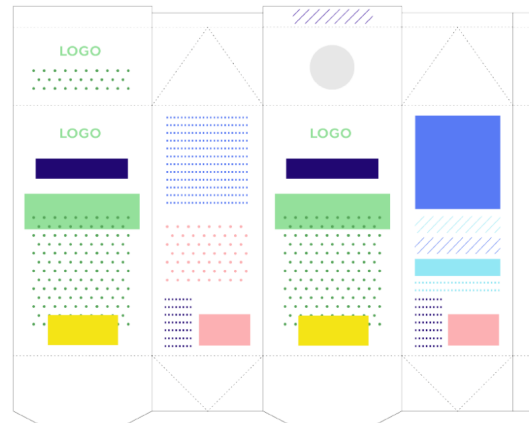


» **Figure 4:** Two different versions (a and b) of the analysis of information placement on butter packaging.

Packaging design of milk carton box (e.g., Tetra Pak®)

Milk and yoghurt are not only put into a bottle or flask, but are often also in a carton (e.g. a Tetra Pak®). In contrast to the packaging mentioned in the previous sub-chapters, there is only one version in the carton analysis, as almost all ten samples appear with this data distribution, with the exception of one. The producers of the analysed milk are mostly Slovenian (most of them coincide with the producers listed in the yoghurt content analysis (Table 2)). The following figure (Figure 5) shows the visualisation of the distribution of the data, based on which the graphic image of the packaging was later designed. Similar to the bottle and box versions, the carton has a primary side that is repeated in the same image on the back, which can facilitate the recognition of the product from several directions. The

primary side contains the most important information, namely the logo and product name in the top third, with an additional product description and/or graphic image below. In the lower third, in the middle or on the right-hand side, there are health or nutrition claims.



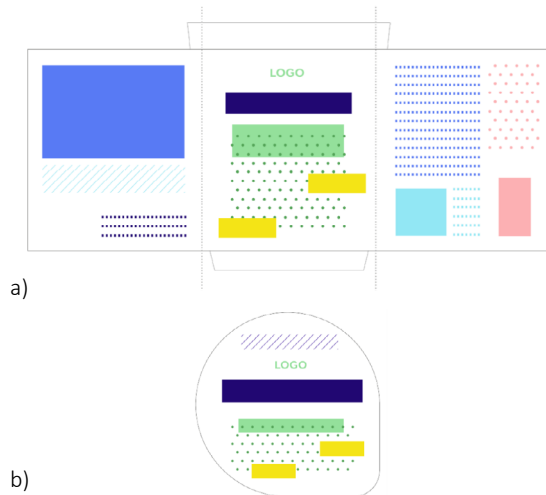
» **Figure 5:** The analysis of information placement on milk carton box.

The repetition of the main page makes sense for cardboard because the areas of the side pages are relatively large (compared to a cereal box), so the rest of the information (ingredients, nutritional value...) is not so compressed and in most cases has satisfactory visibility and recognition. The obligatory information and labels are therefore distributed on the left and right side according to the main page. A table with the nutritional value of the food appears on one of the pages, and there are pictograms below it. At the bottom of the page is the barcode EAN-13 and the net quantity, which is also repeated on the opposite page. On the opposite side is a list of ingredients, followed by the storage conditions and the instructions for use, and below that the manufacturer and the origin. The expiry date is usually on the top flap above the cap on the primary side.

Packaging design for yogurt container

In the design of yoghurt packaging, the first page is the primary page, which is centrally aligned as with all the food groups analysed previously. The company logo and product name are in the top third or half of the label, while the bottom third or half features a graphic image and additional description of the product (Figure 6a). Nutrition information is located in the lower half of the label on the left or right side. The repetition of the primary side could only be distracting on the pot, as the label of the pot is much smaller than the other described packages. As a result, the other data would be too compressed and more difficult to distinguish. The obligatory information and labels are on the right and left side of the main page. On one of the pages is the nutritional value of the food with manufacturer and origin in combi-

nation with the barcode EAN-13 and other labels. On the second page there is a list of ingredients with allergens, followed by the storage conditions. In most cases, the net quantity appears on only one page, usually as close as possible to the first page so that it can be noticed earlier. The second part of the analysis of the pot includes the lid (Figure 6b), which in most cases is almost identical to the primary side of the label. All the information is the same and differs only slightly in layout from the primary side as it is adapted to the round shape of the lid. The expiry date also appears on the lid. It is often printed directly above the dates and is difficult to see in these cases.



» **Figure 6:** The analysis of information placement on yogurt container a) side and b) lid.

Results for a colour coding and labelling system on packaging for dairy products and cereals

Previous research and the results of analyses of food packaging have shown that declaration information can be very inaccurate and incomprehensible. In our design, we have not removed the declarations and other information about the food on the packaging, but only added labels that make it quicker and easier to determine the amount of sugar contained. With the help of an analysis of labelling systems on the world market, we designed labels that are clear and distinct. Several versions of the scale have been developed, divided into a multi-coloured (colour-coded) scale containing data presented in words or letters. For each version of the scale, the best placements on the packaging (front or back) are presented. What the tables have in common is that they all contain the same information and that this data is presented with the same typographic choice.

Coding system (colours and typography)

The multi-coloured scale was created with the aim of identifying the sugar content in products more quick-

ly and easily. The colour coding enables a clearer and more concise determination of the content of sugar contained, so that the customer can obtain the desired information more quickly. Colour codes have been assigned to the classes, allowing the customer to make both an intuitive and a logical connection between the amount of sugar and the colour it represents.

The colours used to create the scale were selected based on the analysis of existing scales and research conducted in 2015 (Wąsowicz, Styśko-Kunkowska & Grunert, 2015; Huang & Lu, 2015). Thus, five different colours were selected that are similar in terms of saturation and brightness, as shown in the following figure (Figure 7). The colours appear coherent and harmonious with each other, and they can also be seamlessly integrated into the existing packaging while still being visible and clear. The colours tend to be pastel or slightly less saturated colours of medium brightness, as they can still be perceived quickly but would not distract the shopper's attention from the product itself and other information.

On the scale, the colours follow each other exactly as they do in nature on the colour spectrum of visible light. The colour blue is assigned to the lowest sugar content and green to the next class, as these colours are perceived as the healthiest according to research. Moderate sugar content is represented by a neutral yellow colour, followed by an orange colour with an amber tint, which is also common in this role in existing labelling. The highest sugar content is indicated by a pink hue that is not too noticeable and aggressive, but still conveys unhealthy eating habits due to excessive sugar consumption. The scale (Figure 7) is minimalist and refined, with an elongated rectangular shape. The classes are divided into smaller frames, edited by white stripes connected to the background. The primary and secondary information for each class is separated by negative space that creates an arrow pointing to the associated data. The corners of the shapes are slightly rounded and express a friendly, yet clean visual appearance.



» **Figure 7:** Selected colours on a multi-coloured scale.

The information contained in the sugar content scale is divided into two important information as primary and secondary. The primary information is the most important and gives the name and meaning of the class of sugar contained (very low, low, moderate...). The secondary information is more specific and would not be essential in itself (a certain interval of the amount of sugar in the class). So that the data frames themselves are not cluttered and skewed, we have added the meaning of the data or the description of the scale below the frame,

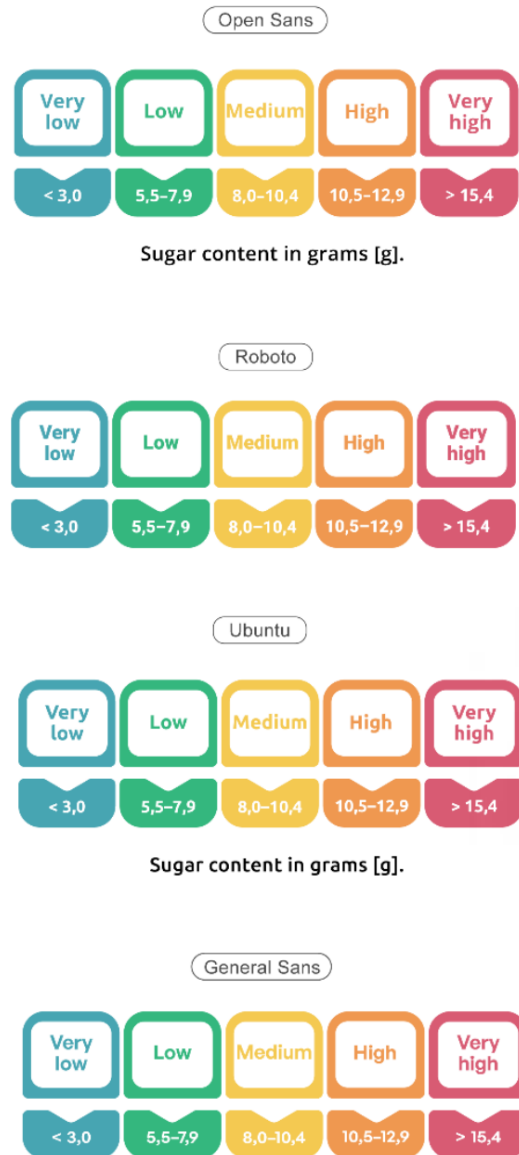
namely "sugar content in grammes [g]". Based on the analysis of the practise of existing labelling methods, we have identified two ways to present primary information (Figure 8a). The first option is to use words to describe the increasing classes, i.e. very low, low, moderate, high and very high sugar content. The word extreme is used for extremes as it expresses a large amount or a high level, i.e. a level that is even higher compared to the previous/following class (high/low). Words are written in lower case because they have a more recognisable counterpart form and are consequently easier to read or recognise (Tinker, 1963). According to research conducted in 2022 (Weingerl, Nedeljković & Pušnik, 2022), we used words with upper case letters (sentence structure) because they are recognisable earlier compared to words with only lower-case letters. Another way to present primary information is to use letters, using the Nutri-Score labels as an example (Figure 8b). In the alphabet of the consecutive letters A, B, C, D and E of the extra bold version, capital letters are used.



» **Figure 8:** Two different variations of the multi-coloured scale a) with words and b) with lettering.

In choosing the font for the text of the scales, we have paid particular attention to the legibility of the font in a small size or letter height. A font with characteristics that make it easier to read, namely a high central letter belt (x-height), moderately wide letterforms, i.e. avoiding compressed and narrowed typefaces, and a relatively low contrast between bold strokes, has been chosen. We also made sure that the font we chose had recognisable counterforms of the letters, as these are easier to see at smaller sizes (Jones et al., 2019). For this reason, lower-case letters for the text were chosen, but it was important that the font had as many different letter shapes as possible, e.g. b, p, d and q are not just mirrored but matched and there are no substitutions of letters (e.g. lowercase c and o, lowercase l, uppercase i and the number 1 or uppercase B and 8) or combinations of letters (e.g. lowercase r and n do not become m or lowercase c and l become d). We also wanted to avoid substituting letters by using bicular lowercase a and g instead of monocular ones. From the beginning, we refrained from using hand-drawn and handwritten fonts, as their legibility at lower levels is questionable in most cases. Therefore, we decided to use only a serif or sans-serif

font, choosing a linear font (i.e. without serifs) because in our case there is very little text on the scale, i.e. we had no serifs to help guide the eye when reading longer texts. needed. By choosing a sans serif font, we also wanted to add a level of seriousness and objectivity to the information that is often lost with serif fonts. The following figure (Figure 9) compares the fonts that were most suitable for the type of use and met our requirements, namely Open Sans, Ubuntu, Roboto and General Sans.



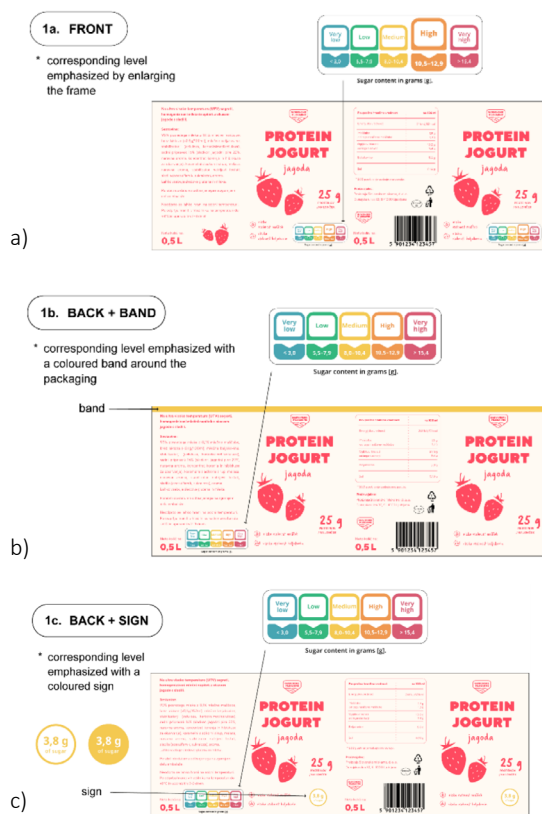
» **Figure 9:** Examples of selected typography.

The font Open Sans (by Steve Matteson), which best reproduces all the above characteristics, as it is less narrow and has a slightly higher central letter area compared to the Roboto font has been chosen. When we compared Open Sans with the General Sans font, we found the letterforms themselves slightly more recognisable and readable. In the final phase, we chose between Open Sans and Ubuntu fonts, whose letterforms have a more modern and fun look, but we still chose Open Sans

because we have a choice of monolingual and bilingual lowercase g and relatively more familiar or established letterforms that can inspire a sense of confidence in the consumer. The advantage of the Open Sans font is also the end of some base strokes next to the circles, where the end of the base stroke is narrower, which consequently helps to avoid larger blacks in smaller letter sizes.

Options for placement on the packaging

It was also important to consider the possible placement of the scale on the packaging so that it is logical, quickly noticeable, but not distracting in relation to other information about the food. The following figure (Figure 10) shows different placements of the scale on one of the produced packages, which will be described in more detail in the continuation of the thesis (chapter Designed food packaging and placement of scales).



» **Figure 10:** Three different variations of code placement to the packaging a) front, b) back with band and c) back with sign.

The first of the layout variants for the multi-coloured scale is on the primary side in the lower left or right third, which is also the most common arrangement in practise. When placing the scale on the primary page, the corresponding class would be highlighted by an enlargement of the frame and a bolder version of the font (black version) compared to the rest of the data (middle version), depending on the amount of

sugar contained in the food. The advantage of placing the scale on the primary side is faster and direct access to all the sugar content information, but it can often be somewhat distracting on the most graphically complete (primary) side of the packaging.

Another option is to attach the scale to the side or back of the package. In this case, the scale frames and the font version are the same for all classes, and the corresponding class can be highlighted in two ways. In the first method (1b), the corresponding amount of sugar is indicated by a coloured band enclosing the upper part of the packaging, the width of which is between 2.0 and 3.5 % of the height of the packaging. This allows the buyer to see the information more quickly from all sides without obscuring other data and the graphic image of the packaging. In the second method (1c), which also has a scale on the side or back, the corresponding class is highlighted on the primary side by an ink mark that can contain only the class name or the exact amount of sugar contained. Like the colour strip, this mode allows for quick recognition of important information and less degradation of the primary page image.

Final packaging and coding positions

To facilitate the presentation of the designed packaging and scales, 3D models of the packaging for each food group were created. A model of a cardboard box, a bottle or vial with a label, butter with a wrapper, a carton for milk or yoghurt and a plastic cup with a label and a lid were designed. The models were also designed using simpler modelling techniques with a cube and with subdivision by adjusting the points and sides of the polygon. It was important to design a model at a realistic scale so that the sizes of the packages were in proportion. Simple techniques such as movements, rotations and cutting out were used in the initial modelling. The figures (Figs. 11a-11e) show the final visualisations of the packages of the multi-coloured coding.

Conclusions

Due to the increasingly frequent occurrence of hidden sugars in dairy products and cereals, a labelling system has been developed to raise awareness of sugar content and facilitate enquiries. In this work, the sugar content of 49 samples of yoghurt products was analysed, which allowed us to first design a scale based on sugar amounts with five increasing classes. An analysis of the content and placement of information on the packaging of dairy products and cereals offered on the Slovenian market was carried out. On this basis, the graphic image of the imaginary brand was designed and the developed labelling system was placed so that it functions holistically and coherently. When analysing the existing methods of nutrition labelling, we came



» **Figure 11:** Code placement to the packaging for different products a) cereals, b) yogurt in a bottle, c) butter, d) milk and e) yogurt in a container.

to the conclusion that there is not yet a uniform labeling system for sugar content on the Slovenian market. Therefore, different design solutions were designed and compared, which differ from each other in terms of format, colours and interpretability (graphic visualisations). Two types of scales were designed, that differ in the presentation of the most important information. Thus, a multi-coloured scale with word or letter representation of the main information and a coloured scale with symbols or a pattern instead of the main information were created. The optimal placement of the scales on the packaging was prepared in such a way that the information about the amount of sugar is recognised first by the customer but is not destructive in relation to the existing graphic image. The graphic image of our packaging was inspired by the samples analysed and gives a refined, natural and slightly playful impression. The result is a basic outline of the packaging for each food group, with two options presented in each case, the first with a multi-coloured scale in different positions and on different packaging. When designing the labels, further use was important as they could later be used on other food packaging. In the future, additional

research such as surveys and questionnaires should be carried out, which would allow more constructive decisions to be made regarding the presentation of information and aesthetics. The final labelling system could reduce confusion about the sugar content of foods and help consumers achieve their desired dietary habits.

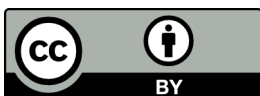
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A new approach for effective productivity management of newspaper printing press

ABSTRACT

Within the modern commercial printing press, a common problem is the efficient management of the maintenance of different machines of newspaper printing press. If Effective Maintenance Management is applied, productivity of the machines can be increased by reducing breakdown time of the machine. Productivity Management is an organizational framework that helps machines to improve productivity. Productivity of a machine is dependent on the failure probability which can be controlled by technical and management actions. The present investigation is established by the analysis of productivity, effectiveness and failure probability on the basis of Pareto Analysis. Pareto chart is also developed to understand the actual scenario where highest priority events are sequentially arranged. It has been observed that the web-offset printing machine has the highest productivity and effectiveness with less failure probability while the exposure unit has the highest failure probability having low productivity and effectiveness. Based on the reduction of probability of failure to meet the acceptable criteria, further maintenance planning can be suggested. This approach confirms that productivity and effectivity of the machines of newspaper printing press can be increased by considering consequences of the machines and their corresponding failure assessments.

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KEY WORDS

Total productivity, partial productivity, overall effectiveness, failure probability

Introduction

Productivity performance plays a vital role in manufacturing industry and it has been important aspects for improving the quality of finished product as well as reputation of manufacturing house. Recently, in developing country like India, the issue of a improvement of partial productivity and total productivity has become most important aspects for any manufacturing house.

There are various types of machines needed for printing press with advances in technology. During the printing process there exists different types of scraps and wastages in the press that need to be handled and minimized. This is where requirement of productivity and profit measurement exists. The print production house is one of the labor intensive manufacturing firm that contribute to economy growth of India.

Productivity is the important factor for a press to achieve maximum outputs in required time with less cost.

Machine productivity is the measurement of a machine's proficiency in converting the raw inputs into useful products. In the present investigation an attempt has been made to make a quantitative assessment of productivity, effectiveness and utilization of several machines used in a commercial newspaper printing press.

In this press one web-offset printing machine and three prepress equipments are examined for the study. Partial and total productivity of different machines are measured with the help of selected resources such as labor input, capital input, material input and miscellaneous inputs etc. Productivity improvement has become a important issue (factor) for policy makers, strategic planner and top level management as it is becoming a key factor affecting the overall effectiveness of press/productivity.

tion house. It is observed that productivity and effectiveness of an equipment can be increased by implementing Effective Maintenance Management (EMM) of machines in a newspaper printing press. Productivity is a Key-Metric to measure the efficiency of any costly equipment for the implementation of Total Productivity Maintenance (TPM) philosophy.

The target is the highest productivity of a costly equipment for the improvement of effectiveness and best possible return of the facilities. Based on the existing problems of machines of newspaper printing press, a proposed methodology has been suggested by conducting an in-depth analysis of variation of different input costs as well as production time and breakdown time.

Literature Review

Some works in the domain of measurement of productivity and effectiveness of manufacturing machines have been done by various researchers. A framework for productivity analysis of maintenance management had been studied (Kutucuoglu et al., 2001) by using performance measurement system. In another study (Hernandez et al., 2006), different performance parameters like overall effectiveness, big losses had been evaluated for a manufacturing process. Several invisible losses like speed loss, startup loss etc. had been studied in detail (Olivier, 2007) to implement total productive maintenance in manufacturing and assembly industry.

A systematic process planning and implementation of robust framework of maintenance had been successfully applied (Sivakumar & Saravanan, 2011) for the increment of both partial productivity and total productivity in textile fabric industry. Analysis of productivity of printing machines had been studied (Kumar, Varambally & Rodrigues Lewlyn, 2012) and later overall effectiveness of printing machines had also been measured in a study (Kumar, Shetty & Rodrigues Lewlyn, 2014). Different metrics like Productivity, Utilization, Uptime factors etc. for printing and manufacturing industry were analyzed (Spencer, Fiasconaro & Sahay, 2014) by using a software. It is seen that overall effectiveness-based analysis on Radio-Frequency Identifier (RFID) based automatic process had shown more accuracy than manual process of tool management (Dovere, Cavalieri & Ierace, 2017).

OEE framework had been applied successfully in different sustainable manufacturing industries (Maideen et al., 2015) (Poorya, Aydin & Majid, 2018). The effect of non-added value (NVA) activity related to maintenance throughout the year in manufacturing industry will also act as a important parameter to balance the efficiency measurement for productivity improvement (Wardah et al., 2018). In a cement manufacturing firm, a pilot study (Rabindra & Purushottam, 2019) had been conducted on

the basis of measurement of partial productivity and total productivity. Oni Jaya Motor in Indonesia controlled their production efficiency by daily monitoring of effectiveness and reduced their six big losses by countering the most influencing losses like set up and adjustment of 29.8%, Reduced Speed Loss of 25.6% and Breakdown Loss of 21.3% as well with monthly improvement scores (Setyawan et al., 2021).

Overall effectiveness (OEE) metrics has now been used universally for the identification of potential of production capacity even in multi-productive system by some researchers (Corrales et al., 2020; Li, Liu & Hao, 2021). Also, in the domain of small-medium scale enterprise or any automotive industry a novel approach has been developed which is offering the world with high class availability, performance, quality, OEE, TEEP, productivity etc. (Tayal et al., 2021).

However, total factor productivity (TFP) plays a key role for the development of technological progress in industry and recently it is shown that TFP of high tech industries in China is upward by applying Malmquist and Hicks-Moorsteen indices (Chen, Liu & Zhu, 2022).

In the present investigation a new frame work has been designed on the basis of production time, number of failures and its associated costs for the measurement and improvement of Total Productivity (TP) along with the overall effectiveness and utilization to understand the exact Return on Investment (ROI) of the newspaper printing press.

Materials and Methods

Productivity

Print production requires various material and immaterial inputs to produce finished outputs. It needs some measure to track its inventory, production status and profit analysis. Here the concept of productivity arises for measuring various inputs in terms of cost or time etc. The production function represents production performance and productivity to improve final outputs. So, Productivity is defined as a ratio of aggregate volume of output measure of actual product to a volume input measurement of consumed resource in making the product or providing the service.

Productivity in terms of time ($|TP|_{Time}$) is also measured by the ratio of actual production time or runtime to potential production time. Uptime is the ratio of actual production and idle time to the total available production time (which includes the runtime, breakdown time, repair time, idle time etc. but excludes schedule breaks i.e. all available time per shift/day/week).

Productivity and uptime are expressed by Equations 1&2. Potential production time is nothing but the usable time period of operation which includes runtime and downtime but excludes idle time (Spencer, Fiasconaro & Sahay, 2014).

$$|TP|_{\text{time}} = \frac{\text{(Actual production time (or runtime))}}{\text{Potential production Time (or planned production time)}} \quad (1)$$

$$U_{\text{ptime}} = \frac{\text{(Actual production time + Idle time)}}{\text{Available all time per shift or day or week}} \quad (2)$$

To understand the better scenario of productivity in terms of cost, Total-Factor Productivity (TFP) is used to access the quick commercial productivity in the industry. It is the ratio of net output and total factor input where net output is the total output excludes intermediate purchased goods and services and total factor input includes labor inputs & capital inputs as shown in Equation 3. But the limitation of TFP is that net output does not consider the efficacy of production system in a proper way as inputs like material, energy, services are ignored.

Multi-factor productivity (MFP) is introduced on the basis of soft factors like people, organizational system, work method, management styles which is easily changeable. It can use instantaneous needful inputs and can easily excludes the non-required inputs to monitor daily productivity index for better understanding of performance rate with available resource as shown in Equation 4.

$$\text{Total factor productivity (TFP)} = \frac{\text{Net output}}{\text{Total factor input}} = \frac{\text{Total output}}{\text{Labour, material, energy, service \& other inputs}} \quad (3)$$

$$\text{Multi-factor productivity (MFP)} = \frac{\text{Total output}}{\text{Total input excludes specified parameter (like capital inputs etc)}} \quad (4)$$

The important mathematical expression of total productivity (TP) along with its supporting factor like partial productivity (PP) and weightage factor are given in Equation 5, 6 and 7. Therefore, total productivity is the ratio of total aggregate output (Oi) to aggregate input (Ii) of i^{th} product/day/week/event. Also, " I_i " is the summation of all the individual j^{th} factor of input (where, j : {material (M), energy (E), human (H), capital (C), maintenance & other expenses (X) etc.}). Partial productivity (PP) index is the ratio of total output (Oi) to one class of input (I_{ij}) and weightage factor (W_{ij}) is the ratio of instantaneous one factor input (I_{ij}) to the total aggregate input (Ii) i.e. " $\sum I_{ij}$ ". Also profit% ($\pi\%$) is related to total productivity is shown in Equation 8. It is important to note that for 100% productivity, profit is zero and if productivity is less than or more than 100% then we can calculate the loss and profit margin.

$$TP = \frac{\text{Total aggregate output (Oi)}}{\text{Total aggregate input (Ii)}} = \text{Partial productivity (PPij)} \cdot \text{Weightage (Wij)} \quad (5)$$

$$PP_{ij} = \frac{\text{Total aggregate output (Oi)}}{\text{One factor input (Iij)}} \quad (6)$$

$$W_{ij} = \frac{\text{One factor input (Iij)}}{\text{Total aggregate input } (\sum_j I_{ij})} \quad (7)$$

$$\pi\% = \frac{(O_i - I_i)}{I_i} \cdot 100\% = (TP - 1) \cdot 100\% \quad (8)$$

The productivity can also be considered as an important dimension for introducing TPM program along with OEE in the printing and other industry for production audit and production performance with the special reference to profit percentage.

Also, from the above study we can re-estimate the Combined overall press equipment productivity (COPEP) i.e. the summation of all the useful press equipment productivity (where k stands for number of equipment considered) as shown in Equation 9 to understand the total press expense in terms of total productivity.

$$COPEP = \sum_k TP = \frac{|\text{Total output}|_k \cdot |O_i|_k}{|\text{Total input}|_k \cdot |I_i|_k} \quad (9)$$

TEEP

From the theory of overall equipment efficiency (OEE) and utilization factor of a particular equipment, total effective equipment performance (TEEP) is derived.

TEEP directly deals with the actual production scenario of an effective time taken for usable output from the available total time for production per shift day or week or month. By definition TEEP is the product of OEE and Utilization Factor as shown in Equation 10.

$$\text{TEEP} = \text{OEE} \cdot \text{Utilization Factor} = (\text{Availability} \cdot \text{Performance} \cdot \text{Quality}) \cdot \text{Utilization Factor} \\ = \frac{(\text{Good pcs}) \cdot (\text{Cycle time})}{(\text{Total planned production time})} \cdot \frac{(\text{Total planned production time})}{(\text{Available all time per shift or day or week})} \\ = \frac{(\text{Good pcs}) \cdot (\text{Cycle time})}{\text{Available all time per shift}} \quad (10)$$

Press Details

In this present study, data are obtained from a commercial newspaper printing house situated in Kolkata, India, during August-October, 2018.

The newspaper house consists of different types of machines with its supporting equipment out of which four equipments are selected on the basis of age, criticality factor and high-risk scenario for this pilot study.

These machines are: one Web-offset printing machine, two Computer-to-Plate (CTP) machines, one exposure unit. The web-offset printing machine [Make: The Printer's House, India; Model: Orient Xcell (3c-1)] of the press is basically a four colour web-machine installed in the year 2009 which is used for printing newspaper, book, magazine etc.

This indicates that the web-offset machine under the study can only handle the paper substrates and for this normal web-offset inks and consumables are used. Its daily capacity is 40000 to 41200 pieces of newspaper per hour. Press is using two Epson Sure-Colour T5270 (Ultra Colour XD ink) CTP machines which is installed at 2009 and 2014 for image printing on Aluminium or polyester plate.

Once the plate is imaged, it is exposed by the ultra-violet ray in Technova Proteck Ecolux-i, Exposure machine, installed at 2005.

Press is using Corrective or Breakdown method for the maintenance of the machines and this motivates towards further investigation on strategic planning for improvement of productivity and effectiveness. During this study, the average temperature inside the press was 27 – 33°C and average relative air humidity was 75 – 85%.

Moreover, as the printing job is mostly associated with newsprint thus the press uses the paper of the same grammage and printing is done mainly in night shift though 30% of the printing was done in both day and night shifts. Furthermore, it is assumed that the operational conditions are the same for all the machines.

Proposed Frame-work

In the workflow of every commercial printing house, all the printing jobs are handled on high priority basis. Generally printing equipment works for both single, double or triple shifts a day based on the job pressure in the organization. The demand of jobs is directly related to production capacity and job handling approach.

But it is also necessary to monitor the machine's health, production rate, breakdown, root-causes of faults and maintenance procedure in terms of both time and cost to make proper performance planning.

The present study involves the identification and documentation of all parameter leading to the estimation of overall equipment effectivity metrics and productivity.

Moreover, this work is focused to examine the correlation among the potential parameters like OEE, Utilization Factor along with different kind of productivity metrics to fix a scale of reference for maintenance planning.

Finally, comparative analysis between all the factors is done on the ground of failure analysis, productivity analysis and effectiveness of equipment to establish the suitable maintenance technique. The flowchart given in Figure 1 represents the proposed framework of the methodology.

Results

Productivity

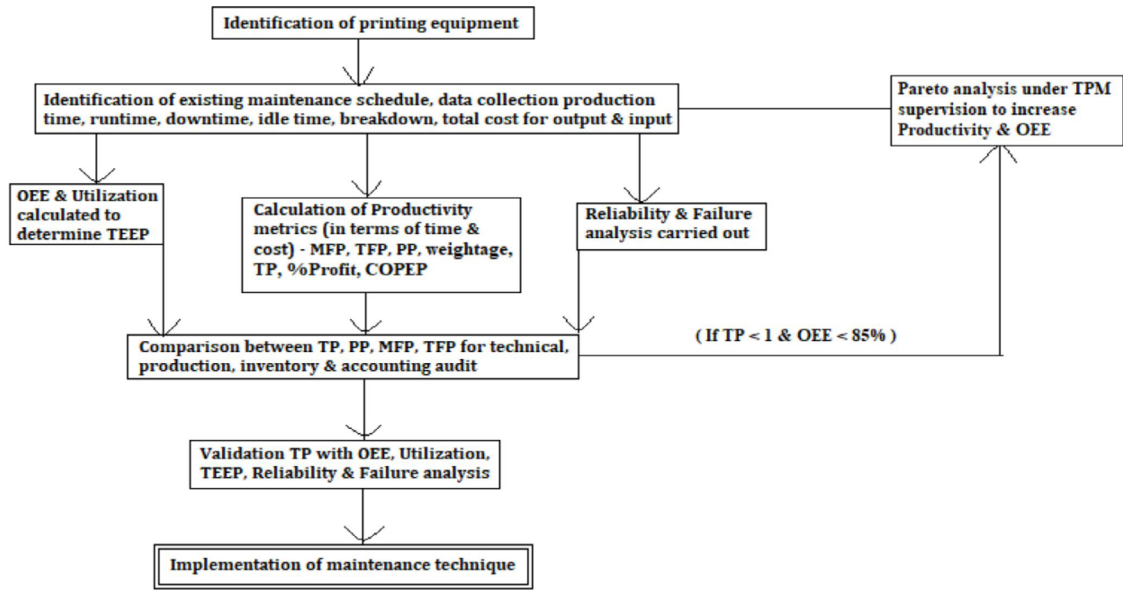
Productivity estimation is the most important part of a printing press for performance and apparent profit analysis. In this study, four equipments (namely web-offset printing machine, CTP1, CTP2 and exposure unit) are chosen in a conventional commercial printing press. Therefore, production audit is necessary to carry out different productivity metrics. If there is any kind of major breakdown during operation of vital machines and its supporting sub-components then it may arise huge loss which may reflect yearly financial turnover and upcoming budget planning. Therefore, it will also affect the future expansion of the press including expansion of company's client and staffs.

Basic data are collected from the commercial press includes runtime, planned production time and idle time in hours of each equipment for consecutive thirteen weeks. These representative data of different types of production time of web-offset printing machine and other prepress equipments are given in Table 1. These data are used to estimate productivity with respect to time, uptime and utilization by using Equations 1, 2 & 10.

Different input cost for different types of machines are collected from the press and given in the Table 2 to Table 5. The input costs of different machines include material cost, cost of energy consumption, maintenance cost and human wages. Here cost of spare parts and cost of repairing has been considered as maintenance cost. Multi-factor productivity (MFP) and profit percentage of different machines has been calculated for different weeks by using Equation 4 and Equation 8 respectively. Moreover, partial productivity (PP) and weightage factor of different machines have estimated by Equations 6 & 7 respectively by considering different input cost separately. Finally, total productivity, profit percentage, total factor productivity and multifactor productivity are calculated by using Equations 5, 8, 3 & 4 respectively which are based on total output and input costs for thirteen weeks.

Combined Overall Press Productivity

Table 6 shows the values of Total Productivity (TP) in terms of cost, %Profit, TFP, MFP of four machines for convenience which clearly indicates the scenario of performance of these machines. From these parameters combined overall press equipment productivity (COPEP) is estimated with the help of Equation 9 and found to 1.5271. Considering the fact that profit will be zero for 100% productivity, overall profit percentage is found to be 52.71 (calculated from Equation 8). This indicates that the press is running with profit margin in-spite of loss for one machine.



» **Figure 1:** Framework for proposed methodology

Table 1

Time Productivity for printing machine and prepress equipments

| Parameter | Web-offset printing machine | CTP1 | CTP2 | Exposure Unit |
|----------------------------------|-----------------------------|----------|----------|---------------|
| Max available time (Hour) | 1391.5 | 1046.5 | 1046.5 | 1046.5 |
| Potential production time (Hour) | 362.8333333 | 117.0667 | 61.18333 | 152.9 |
| Actual production time (Hour) | 246.8833333 | 39.9 | 30.75 | 39.11666667 |
| Idle time (Hour) | 1028.666667 | 929.4333 | 985.3167 | 893.6 |
| Uptime | 0.9167 | 0.9263 | 0.9709 | 0.8913 |
| Productivity(in terms of time) | 0.6804 | 0.3408 | 0.5026 | 0.2558 |
| Utilization | 0.2607 | 0.1118 | 0.0584 | 0.1461 |

Table 2 (part 1)

Productivity in terms of cost for web-offset printing machine

| Week | Output Cost (Euro) | Material cost input (Euro) | Energy cost (Euro) | Maintenance cost (Euro) | Human weekly wages (Euro) | Multi-factor-productivity (MFP) | %Profit |
|------|--------------------|----------------------------|--------------------|-------------------------|---------------------------|---------------------------------|---------|
| wk1 | 32912.726 | 11927.192 | 340.878 | 10.067 | 433.701 | 2.589 | 158.91% |
| wk2 | 38486.035 | 13928.010 | 399.053 | 14.284 | 433.701 | 2.605 | 160.48% |
| wk3 | 27628.323 | 9974.330 | 323.810 | 16.263 | 433.701 | 2.571 | 157.05% |
| wk4 | 27077.646 | 9832.398 | 305.540 | 10.756 | 433.701 | 2.559 | 155.87% |
| wk5 | 29726.57 | 10839.123 | 375.735 | 567.000 | 433.701 | 2.434 | 143.35% |
| wk6 | 30139.763 | 10875.937 | 332.705 | 11.960 | 433.701 | 2.586 | 158.61% |
| wk7 | 43105.14 | 15642.030 | 487.518 | 20.221 | 433.701 | 2.599 | 159.93% |
| wk8 | 49850.435 | 18063.591 | 585.839 | 23.146 | 433.701 | 2.609 | 160.91% |
| wk9 | 45297.996 | 16373.504 | 509.153 | 25.900 | 433.701 | 2.612 | 161.20% |
| wk10 | 77917.788 | 28139.771 | 798.106 | 28.912 | 433.701 | 2.650 | 165.02% |
| wk11 | 35708.364 | 12930.826 | 355.782 | 6.367 | 433.701 | 2.601 | 160.14% |
| wk12 | 16501.84 | 5979.922 | 172.122 | 6.367 | 433.701 | 2.503 | 150.33% |
| wk13 | 22509.966 | 8192.601 | 247.124 | 5.507 | 433.701 | 2.535 | 153.52% |

Table 2 (part 2)

Productivity in terms of cost for web-offset printing machine

| | Cost (Euro) | Partial Productivity | Weightage |
|--|---------------|---------------------------------|--------------|
| Total output cost (Euro) for 13 weeks | 476862.5923 | - | - |
| Material cost input (Euro) for 13 weeks | 172699.2338 | 2.7612 | 0.56029 |
| Total energy cost (Euro) for 13 weeks | 5233.36549 | 91.1197 | 0.01698 |
| Total maintenance cost (Euro) for 13 weeks | 746.751193 | 638.5830 | 0.00242 |
| Total human wages (Euro) for 13 weeks | 5638.117141 | 84.5783 | 0.01829 |
| Capital cost (Euro) for 13 weeks | 123914.6625 | 3.8483 | 0.40202 |
| SUM of all input (Euro) | 308232.13 | - | - |
| Total Productivity (TP) | → 1.547089177 | %Profit | → 54.7089% |
| Net output (Euro) | 292545.1247 | Total factor input (Euro) | → 129552.78 |
| Multi-factor-productivity (MFP) based on total cost for 13 weeks | → 2.587180686 | Total factor productivity (TFP) | → 2.25811538 |

Table 3 (part 1)

Productivity in terms of cost for CTP1

| Week | Output Cost (Euro) | Material cost input (Euro) | Energy cost (Euro) | Maintenance cost (Euro) | Human weekly wages (Euro) | Multi-factor-productivity (MFP) | %Profit |
|------|--------------------|----------------------------|--------------------|-------------------------|---------------------------|---------------------------------|---------|
| wk1 | 657.987 | 109.664 | 8.823 | 3.075 | 57.827 | 3.668 | 266.79% |
| wk2 | 747.205 | 124.534 | 9.437 | 3.121 | 57.827 | 3.833 | 283.34% |
| wk3 | 680.291 | 113.382 | 12.827 | 5.324 | 57.827 | 3.593 | 259.26% |
| wk4 | 568.768 | 94.795 | 10.290 | 322.843 | 57.827 | 1.171 | 17.09% |
| wk5 | 646.835 | 107.806 | 8.049 | 2.662 | 57.827 | 3.668 | 266.80% |
| wk6 | 613.378 | 102.230 | 10.270 | 4.050 | 57.827 | 3.518 | 251.75% |
| wk7 | 769.510 | 128.252 | 9.199 | 2.949 | 57.827 | 3.882 | 288.20% |
| wk8 | 914.490 | 152.415 | 14.929 | 5.806 | 57.827 | 3.959 | 295.92% |
| wk9 | 758.358 | 126.393 | 12.550 | 4.922 | 57.827 | 3.760 | 276.00% |
| wk10 | 814.119 | 135.687 | 10.349 | 3.465 | 57.827 | 3.927 | 292.67% |
| wk11 | 702.596 | 117.099 | 12.570 | 5.106 | 57.827 | 3.648 | 264.79% |
| wk12 | 368.027 | 61.338 | 8.188 | 3.603 | 57.827 | 2.810 | 181.03% |
| wk13 | 602.225 | 100.371 | 11.777 | 4.957 | 57.827 | 3.443 | 244.26% |

Table 3 (part 2)

Productivity in terms of cost for CTP1

| | Cost (Euro) | Partial Productivity | Weightage |
|--|--------------|---------------------------------|--------------|
| Total output cost (Euro) for 13 weeks | 8843.78946 | - | - |
| Material cost input (Euro) for 13 weeks | 1473.96491 | 6.0000 | 0.19159 |
| Total energy cost (Euro) for 13 weeks | 139.256773 | 63.5071 | 0.01810 |
| Total maintenance cost (Euro) for 13 weeks | 371.880986 | 23.7812 | 0.04834 |
| Total human wages (Euro) for 13 weeks | 751.748952 | 11.7643 | 0.09771 |
| Capital cost (Euro) for 13 weeks | 4956.5865 | 1.7843 | 0.64426 |
| SUM of all input (Euro) | 7693.43812 | - | - |
| Total Productivity (TP) | → 1.1495237 | %Profit | → 14.9524% |
| Net output (Euro) | 6106.93784 | Total factor input (Euro) | → 5708.33545 |
| Multi-factor-productivity (MFP) based on total cost for 13 weeks | → 3.23137337 | Total factor productivity (TFP) | → 1.06982813 |

Table 4 (part 1)

Productivity in terms of cost for CTP2

| Week | Output Cost (Euro) | Material cost input (Euro) | Energy cost (Euro) | Maintenance cost (Euro) | Human weekly wages (Euro) | Multi-factor-productivity (MFP) | %Profit |
|------|--------------------|----------------------------|--------------------|-------------------------|---------------------------|---------------------------------|---------|
| wk1 | 278.808 | 46.468 | 4.818 | 1.354 | 57.827 | 2.524 | 152.39% |
| wk2 | 223.046 | 37.174 | 4.322 | 1.067 | 57.827 | 2.222 | 122.18% |
| wk3 | 278.808 | 46.468 | 5.095 | 1.515 | 57.827 | 2.514 | 151.39% |
| wk4 | 412.636 | 68.773 | 6.721 | 1.767 | 57.827 | 3.055 | 205.46% |
| wk5 | 289.960 | 48.327 | 8.208 | 329.213 | 57.827 | 0.654 | -34.63% |
| wk6 | 345.722 | 57.620 | 5.730 | 1.595 | 57.827 | 2.816 | 181.60% |
| wk7 | 345.722 | 57.620 | 6.146 | 1.778 | 57.827 | 2.802 | 180.23% |
| wk8 | 457.245 | 76.208 | 8.129 | 2.352 | 57.827 | 3.164 | 216.40% |
| wk9 | 334.570 | 55.762 | 6.047 | 1.778 | 57.827 | 2.756 | 175.56% |
| wk10 | 345.722 | 57.620 | 5.531 | 1.423 | 57.827 | 2.824 | 182.45% |
| wk11 | 323.417 | 53.903 | 5.749 | 1.664 | 57.827 | 2.715 | 171.45% |
| wk12 | 156.132 | 26.022 | 2.736 | 0.780 | 57.827 | 1.787 | 78.71% |
| wk13 | 256.503 | 42.751 | 3.945 | 0.964 | 57.827 | 2.432 | 143.16% |

Table 4 (part 2)

Productivity in terms of cost for CTP2

| | Cost (Euro) | Partial Productivity | Weightage |
|--|--------------|---------------------------------|---------------|
| Total output cost (Euro) for 13 weeks | 4048.29202 | - | - |
| Material cost input (Euro) for 13 weeks | 674.715337 | 6.0009 | 0.18208 |
| Total energy cost (Euro) for 13 weeks | 73.1772135 | 55.3299 | 0.01975 |
| Total maintenance cost (Euro) for 13 weeks | 347.249364 | 11.6599 | 0.09371 |
| Total human wages (Euro) for 13 weeks | 751.748952 | 5.3860 | 0.20287 |
| Capital cost (Euro) for 13 weeks | 1858.71993 | 2.1783 | 0.50160 |
| SUM of all input (Euro) | 3705.61080 | - | - |
| Total Productivity (TP) | → 1.09247631 | %Profit | → 9.2476% |
| Net output (Euro) | 2201.40115 | Total factor input (Euro) | → 2610.468889 |
| Multi-factor-productivity (MFP) based on total cost for 13 weeks | → 2.19194977 | Total factor productivity (TFP) | → 0.843297219 |

Table 5 (part 1)

Productivity in terms of cost for exposure unit

| Week | Output Cost (Euro) | Material cost input (Euro) | Energy cost (Euro) | Maintenance cost (Euro) | Human weekly wages (Euro) | Multi-factor-productivity (MFP) | %Profit |
|------|--------------------|----------------------------|--------------------|-------------------------|---------------------------|---------------------------------|---------|
| wk1 | 187.359 | 14.870 | 6.580 | 2.907 | 40.479 | 2.890 | 188.97% |
| wk2 | 191.820 | 16.728 | 9.071 | 4.482 | 40.479 | 2.711 | 171.09% |
| wk3 | 189.589 | 14.870 | 7.311 | 3.373 | 40.479 | 2.871 | 187.11% |
| wk4 | 191.820 | 16.728 | 7.807 | 3.662 | 40.479 | 2.793 | 179.31% |
| wk5 | 187.359 | 16.109 | 7.051 | 3.213 | 40.479 | 2.803 | 180.26% |
| wk6 | 189.589 | 16.728 | 8.699 | 4.241 | 40.479 | 2.703 | 170.28% |
| wk7 | 220.816 | 19.207 | 8.538 | 3.919 | 40.479 | 3.061 | 206.08% |
| wk8 | 269.886 | 22.924 | 11.425 | 5.413 | 40.479 | 3.363 | 236.34% |
| wk9 | 218.585 | 19.207 | 9.727 | 4.690 | 40.479 | 2.950 | 194.97% |
| wk10 | 252.042 | 21.685 | 10.211 | 4.803 | 40.479 | 3.266 | 226.58% |
| wk11 | 205.203 | 17.968 | 11.115 | 5.670 | 40.479 | 2.728 | 172.76% |
| wk12 | 104.832 | 12.391 | 6.741 | 3.614 | 40.479 | 1.658 | 65.81% |
| wk13 | 171.746 | 13.631 | 9.405 | 4.843 | 40.479 | 2.512 | 151.25% |

Table 5 (part 2)

Productivity in terms of cost for exposure unit

| | Cost (Euro) | Partial Productivity | Weightage |
|--|--------------|---------------------------------|---------------|
| Total output cost (Euro) for 13 weeks | 2580.64676 | - | - |
| Material cost input (Euro) for 13 weeks | 223.046392 | 11.5700 | 0.08033 |
| Total energy cost (Euro) for 13 weeks | 113.678856 | 22.7012 | 0.04094 |
| Total maintenance cost (Euro) for 13 weeks | 54.8304014 | 47.0660 | 0.01975 |
| Total human wages (Euro) for 13 weeks | 526.224266 | 4.9041 | 0.18953 |
| Capital cost (Euro) for 13 weeks | 1858.71993 | 1.3884 | 0.66945 |
| SUM of all input (Euro) | 2776.49985 | - | - |
| Total Productivity (TP) | → 0.92946043 | %Profit | → -7.0540% |
| Net output (Euro) | 1662.86684 | Total factor input (Euro) | → 2384.944203 |
| Multi-factor-productivity (MFP) based on total cost for 13 weeks | → 2.81183616 | Total factor productivity (TFP) | → 0.697235114 |

Table 6

Performances of machines under study

| | Web-offset printing machine | CTP1 | CTP2 | Exposure Unit |
|---------------------------------|-----------------------------|--------|--------|---------------|
| Total Productivity (TP) | 1.5471 | 1.1495 | 1.0925 | 0.9295 |
| %Profit | 54.71 | 14.95 | 9.25 | -7.054 |
| Total-factor productivity (TFP) | 2.2581 | 1.0698 | 0.8433 | 0.6972 |
| Multi-factor-productivity (MFP) | 2.5872 | 3.2314 | 2.1919 | 2.8118 |

Analysis

Variation of multifactor productivity of all the machines in terms of soft factor (like material, labor, energy, maintenance and other expenses etc.) with number of weeks are shown in Figure 2 and analyzed to understand the profit scenario against weekly variable inputs and to evaluate the material consumption, machine performance and human effort. Figure 3 demonstrates the comparative analysis of total productivity (TP), profit percentage, total factor productivity (TFP), multi factor productivity (MFP) of all the machines under study.

Here TFP value (2.2581, 1.0698, 0.8433 & 0.6972) is estimated for easy sales analysis purpose, MFP value (2.5872, 3.2314, 2.1919 & 2.8118) is calculated for daily basis performance and inventory audit and TP is estimated for actual production audit. This shows that web-offset machine has highest value of TP of 1.5471 resulting highest percentage profit of 54.709% whereas exposure unit shows the lowest TP of 0.9295 having lowest percentage profit of -7.054%. Now, COPEP metrics is giving an overall productivity value 1.5271 and the overall profit of press of 52.71% which may help for further effective management of press for improved productivity. It is also observed that the COPEP value is nearest to the TP value of web-offset printing machine and this is because the output and input value of other machines are also component and sub-component of main web-offset printing machine.

Validation of Productivity with Effectivity

Different performance parameters of the machines of the newspaper printing press are illustrated in Table 7 for comparative analysis. To validate the values of TP of four equipments, overall equipment efficiency (OEE) values of machines are determined by using Equation 10.

Also, total effective equipment performance (TEEP) and utilization factor of all the equipment have been estimated. It is seen that web-offset printing machine possess highest TP value, OEE, Utilization factor, TEEP metric.

The TEEP value is demonstrating the actual performance value of all the machines on the basis of maximum utilized time for production and actual equipment effectivity status. It is previously seen by the authors (Kar & Pal, 2022) that the Failure Probability and corresponding Reliability of web-offset printing machine and associated prepress equipments can be estimated by using the method of Risk Based Maintenance (RBM) strategy.

The values of failure probability and reliability of all the machines are demonstrated also in Table 7.

Figure 4 shows the corresponding bar chart to compare the values of TP, OEE, Utilization and TEEP with failure probability and reliability of the machines.



» **Figure 2:** Weekly variation of Multi-factor Productivity (MFP):
 (a) Web-offset printing machine,
 (b) CTP1,
 (c) CTP2, and
 (d) Exposure unit



» **Figure 3:** Overview of productivity metrics of press

From this it is very much clear that exposure unit has lowest productivity of 0.9295 value, lowest OEE of 0.252235 value & lowest reliability of 0.19399 and highest failure probability of 0.80601. From the productivity analysis, it indicates that exposure unit has lowest production rate. OEE metrics is categorizing the effectivity of the machine in descending order for further corrective and preventive maintenance planning for the improvement of CTP sections. Utilization factor is helping for the job scheduling and capacity planning of all the press equipment. Reliability and failure analysis is demonstrating the knowledge of machine health & life cycle and vast knowledge of failure occurrence to the management for further strategic and breakdown maintenance. TEEP value is indicating for the predictive maintenance of CTP2 as it has lowest value of 0.0231 for further improvement of its performance.

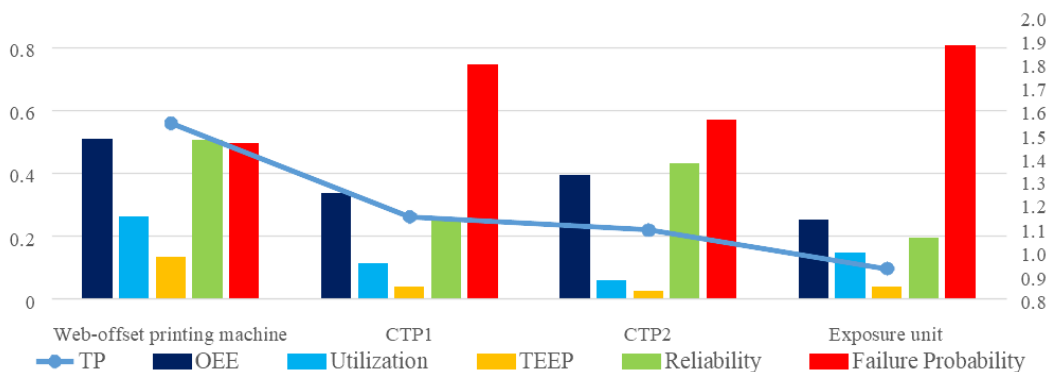
Pareto Analysis

It is pertinent to mention that exposure unit is having the highest failure rate whereas web-offset printing machine posses lowest failure rate which indicates total productivity of exposure unit is very less compared to the web-offset machine. In order to develop further maintenance planning for improved productivity, root-cause of failures of the machines should be analyzed. For this Pareto charts for individual machine can be generated by using statistical software Minitab17. Figure 5 illustrates Pareto analysis for web-offset printing machine which is based on different causes of breakdown and failures. It is observed that loading-unloading of paper reel into web-offset printing machine causes maximum downtime. Similar chart can be easily generated from other machines to identify the causes of failure.

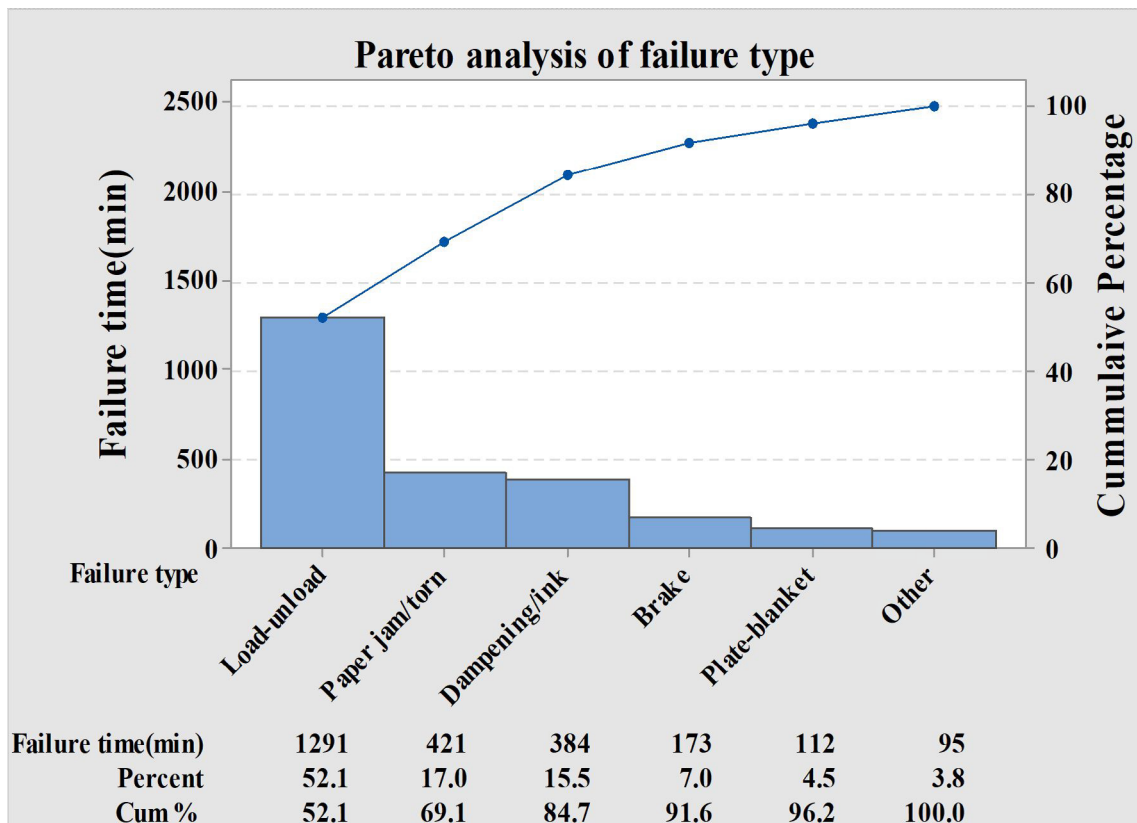
Table 7

Comparative analysis of different effectivity metrics with TP

| Comparison of different effectivity metrics | | | | |
|---|-----------------------------|--------|--------|---------------|
| | Web-offset printing machine | CTP1 | CTP2 | Exposure unit |
| TP | 1.5471 | 1.1495 | 1.0925 | 0.9295 |
| OEE | 0.5082 | 0.3350 | 0.3944 | 0.2522 |
| Utilization | 0.2607 | 0.1118 | 0.0584 | 0.1461 |
| TEEP | 0.1325 | 0.0375 | 0.0231 | 0.0369 |
| Failure Probability | 0.4955 | 0.7455 | 0.5685 | 0.8060 |
| Reliability | 0.5045 | 0.2545 | 0.4315 | 0.1940 |



» **Figure 4:** Comparative analysis of different effectivity metrics with TP



» Figure 5: Pareto chart for Web-offset Printing Machine

Planning for Productivity Improvement

In order to increase the total productivity and overall effectiveness of the equipment, it is necessary to reduce the failure probability of the machines. And for this, further maintenance planning should be implemented. This will help to decrease the number of the failure which in-turn will support the effective productivity management. Table 8 represents the modified productivity (TP, TFP and MFP) along with OEE and utilization factor of all the machines after implementing further maintenance planning. This table also shows the results of failure reduction of all the machines.

The modified probability of failure has been determined by considering the fact that breakdown time or downtime can be reduced by decreasing the number of failures with the help of modern technology and management system. The modified values of effectiveness and utilization factors of all the machines indicate that the modified total productivity of all the machines increases with the increase of effectiveness (modified) of the corresponding machines.

Moreover, the decreased failure probability after modification has shown a strong effect on the improvement of total productivity. So, it can be postulated that the productivity of the machines of the newspaper printing press

can be subsequently increased by applying this methodology which may be useful for the improvement of overall performance of the machines in a printing press.

Conclusion

The proposed technique for productivity and effectiveness analysis predicts the failure frequency and risk pattern of all the equipment in the press. This prediction is used to evaluate the suitable interval of preventive maintenance program based on reducing the failures of the machines.

This methodology confirms that productivity of equipment can be enhanced by implementing further maintenance planning. This will contribute to the effective management of maintenance of printing machines to provide its optimal performance.

The present investigation also helps to identify the high risked machine in a newspaper printing press which involves the need for robust data collection and if the duration of data collection is extended then more accurate result can be achieved. It is concluded that the top management of a printing house has a scope of mechanism to adjust the failure probability of the machines after analyzing the number of failures as a function of interval period between preventive maintenance.

Table 8

Prediction of modified Productivity, OEE and Utilizations of the machines

| Resource | Modified | | | | Existing | | | |
|---|-----------------------------|---------|---------|---------------|-----------------------------|---------|---------|---------------|
| | Web-offset printing machine | CTP1 | CTP2 | Exposure unit | Web-offset printing machine | CTP1 | CTP2 | Exposure unit |
| Output Cost (Euro) | 474980.51 | 8709.96 | 4037.14 | 2580.65 | 476862.59 | 8843.79 | 4048.29 | 2580.65 |
| Material cost input (Euro) | 172141.13 | 1451.66 | 672.86 | 223.05 | 172699.23 | 1473.96 | 674.72 | 223.05 |
| Energy cost (Euro) | 4638.15 | 47.46 | 36.58 | 29.08 | 5233.37 | 139.26 | 73.18 | 113.68 |
| Maintenance loss cost (Euro) | 0.00 | 0.00 | 0.00 | 0.00 | 746.75 | 371.88 | 347.25 | 54.83 |
| Human weekly wages (Euro) | 5638.12 | 751.75 | 751.75 | 526.22 | 5638.12 | 751.75 | 751.75 | 526.22 |
| Capital cost (Euro) | 123914.66 | 4956.59 | 1858.72 | 1858.72 | 123914.66 | 4956.59 | 1858.72 | 1858.72 |
| SUM of all input (Euro) | 306332.06 | 7207.46 | 3319.90 | 2637.07 | 308232.13 | 7693.44 | 3705.61 | 2776.50 |
| Total Productivity (TP) | 1.5505 | 1.2085 | 1.2160 | 0.9786 | 1.5471 | 1.1495 | 1.0925 | 0.9295 |
| % Profit | 0.5505 | 0.2085 | 0.2160 | -0.0214 | 0.5471 | 0.1495 | 0.0925 | -0.0705 |
| Net output (Euro) | 292563.11 | 6459.09 | 2575.96 | 1802.29 | 292545.12 | 6106.94 | 2201.40 | 1662.87 |
| Total factor input (Euro) | 129552.78 | 5708.34 | 2610.47 | 2384.94 | 129552.78 | 5708.34 | 2610.47 | 2384.94 |
| Total factor productivity (TFP) | 2.2583 | 1.1315 | 0.9868 | 0.7557 | 2.2581 | 1.0698 | 0.8433 | 0.6972 |
| Multi-factor-productivity (MFP) without capital | 2.6038 | 3.8696 | 2.7629 | 3.3155 | 2.5872 | 3.2314 | 2.1919 | 2.8118 |
| Productivity (in terms of time) | 0.7196 | 0.7191 | 0.8099 | 0.2620 | 0.6804 | 0.3408 | 0.5026 | 0.2558 |
| OEE | 0.5374 | 0.7038 | 0.6356 | 0.2583 | 0.5082 | 0.3350 | 0.3944 | 0.2522 |
| Utilization | 0.2466 | 0.0530 | 0.0363 | 0.1427 | 0.2607 | 0.1119 | 0.0585 | 0.1461 |
| TEEP | 0.1325 | 0.0373 | 0.0231 | 0.0369 | 0.1325 | 0.0375 | 0.0231 | 0.0369 |
| Failure probability | 0.4741 | 0.6535 | 0.5025 | 0.7995 | 0.4955 | 0.7455 | 0.5685 | 0.8060 |

Moreover, the proposed methodology seems to be novel as it supports not only Productivity Management but also Maintenance Management due to quantitative estimation of failure probability and associated costs of the machines. Finally, it is suggested that this approach may support top management in complying with the requirement of quality print production for enhanced productivity of the equipment.

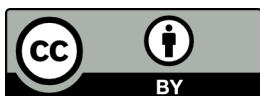
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Young interior designers' creative pattern to draw potential consumers' attention: Expectation, capital, and strategy

ABSTRACT

One of the initial problems faced by young interior designers is to make a creative pattern to draw potential consumers' attention. Their belief in the creative pattern should fit consumers' expectations. This study scrutinized the relationship between young interior designers and potential consumers about both expectation, designers' capital, and designers' strategy to capture the pattern in the design market. To this end, young interior designers (n=100) and potential design consumers (n=100) were recruited as respondents. Multiple linear regression and ordinal logistic regression were applied. The data analysis result demonstrated young designers' marketing patterns to draw potential consumers' attention. A correlation was found between young designers and design consumers. The expectation, capital, and strategy of designers were found to be interrelated by 48.1%, while those of consumers were interrelated by 28.6%. The research variables, which are designer capital, designer strategy and the two respondent groups, were found to have an impact on the expectation by 94.5%. This study concludes that young designers have a marketing pattern to draw potential consumers' attention. It showed a relationship between designers' and consumers' expectations, designers' capital or information received by consumers, and designers' strategy. This study may serve as a reference for young designers' behaviors when entering the market design.

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Introduction

The first challenge young designers should tackle when entering a market design is the increasingly competitive market among design department graduates (Edena & Marniati, 2020).

Therefore, young designers requires a method to overcome this challenge. In principle, young designers would develop their own creative patterns to draw potential consumers' attention (Ashton, 2015).

To attract the attention of consumers, it will certainly be related to the marketing concept. Designers typically hold their own beliefs about their marketing concept when entering a design market (Kotler & Keller, 2012).

Designers and design consumers need to pay attention to this belief and expectation.

In order to be skillful in this industry, Belton's (Belton, 1996) theory of the element of art highlights the importance of visual messages to serve as the first capital when entering a design market.

This capital can be a designer's preparation to develop their quality. It is very important to develop the quality to be able to compete in the global market (Aziz & Larzo, 2014).

In order to be a quality designer, an individual needs a strategy to ensure customer satisfaction (Kotler & Keller, 2012).

State of The Art

Designers and design consumers need to pay attention to this belief and expectation. The relation between designers' and consumers' expectations will achieve the marketing goal effectively and efficiently (Kotler & Keller, 2012). Expecting the market's preferences and needs is an essential factor.

Designers need to know well the market's preference and needs then make visualizations according to orders to satisfy these consumers (Aziz & Larzo, 2014). The creative industry revolves around the fulfillment of consumers' needs, individual preferences, and styles while maintaining company's profitability along with technological advancement in order to shift consumers' expectation (Edena & Marniati, 2020). Therefore, the expectation of an increased market target is possible to maintain the company's profit.

In order to be skillful in this industry, Belton's (Belton, 1996) theory of the element of art highlights the importance of visual messages to serve as the first capital when entering a design market. The following are some of the points that designers have, such as designer's background is one of their primary capital. Their experience before or when marketing their design could be an additional skill to compete in the creative industry. Designers form a unique identity to present the product or service offered (Aziz & Larzo, 2014).

The designer needs to have a certain concept to master, and their concepts will likely grow when they look for broader knowledge. Design knowledge would be easier to receive by designers from digital applications (She, 2021). The formation of unique identity is needed to develop public perception and exhibit the designers' quality to the public. It can increase consumer satisfaction (Kim & Heo, 2021).

It is very important to develop the quality to be able to compete in the global market (Aziz & Larzo, 2014). In order to be a quality designer, an individual needs a strategy to ensure customer satisfaction (Kotler & Keller, 2012). Marketing strategy is the tool that designers utilize for this purpose. The word of mouth marketing strategy is often done but the design business will not develop (Aziz & Larzo, 2014).

Considering the limitation of a business will not develop, designers come up with another marketing strategy. While today's applications like Instagram, Youtube, or websites offer ease of marketing, they also draw consumers' attention when looking for interior design service advertisements (Hendriyani, Nuzuliya Inayati & Regiasty, 2022). Designer's review about the digital competitors are necessary to show the effectiveness of this strategy (Aziz & Larzo, 2014).

It can be seen from platforms such as social media that are frequently used. The existence of social media are connected to find potential consumers (Izadpanah & Gunce, 2021). The relationship between consumer interest resulting from using this strategy expand the marketing area and more effective bargaining (Taylor & Strutton, 2010). The digital approach also leads designers to other required strategies. Technological developments affect the communication between the designers and consumers (Aziz & Larzo, 2014).

Consumer data collection become more effective to obtain the relevant data from the feature digital application (Hendriyani, Nuzuliya Inayati & Regiasty, 2022). In addition, there are issues that designers need to consider when it comes to the consumer. Determining the value of the work is not only the responsibility of the individual (Haddad, 2014).

It implies that the responsibility is held by both the designer and the consumer. The strategy are needed because the consumers also have the power to influence and compare prices (Aziz & Larzo, 2014).

A previous study has revealed that designers' problems when entering the design market lie in their preparedness and awareness (Ashton, 2015). Another study proposes solutions to prepare a good design through a presentation strategy consisting of form, content, and context (Oscario & Zahra, 2018).

Edena and Marniati's (Edena & Marniati, 2020) work scrutinizes possible media that can be used as a designer's capital to work in the future. The current design study curriculum that has not been updated according to market conditions affects students who will work in the future so guidance is needed to develop the target market, in order not just theoretical so the students complete their study period and process their work properly (She, 2021).

The quality of competent graduates will affect the effectiveness of work performance so the supervisors and professionals need to work hand in hand to educate students more integrated and strategic (Wong, Zaffwan Idris & Tan, 2021).

Built upon previous works, this study attempted to analyze the relationship and also compared these two groups (i.e., designers and consumers) in order to find out the young designers' patterns when entering the design market.

This paper examines the relationship between designers and consumer's expectations, designer's capital, and designers' strategy in order to find out the young designers' marketing pattern to draw potential consumer's attention.

Material and Methods

This quantitative study primarily aimed to analyze the relationship between designers' and consumers' expectations, designers' capital or information obtained by the design consumer, and designers' strategy. This study also compared these two groups (i.e., designers and consumers) in order to find out the young designers' patterns when entering the design market.

The scope of this study was limited to Solo, Central Java, Indonesia. Applying Lemeshow's formula, Participants were recruited from the population of young interior designers between 16 and 30 years of age, following the definition of youth stipulated in Law on Youth (n=100). Another group of participants was also recruited from the population of interior design consumers (n=100).

A probability sampling technique was applied. Thus every member of the population stood a chance to be selected as the study participant. Prior to their participation, they were informed about the study and signed a consent form. This study has also been approved by the research council of the faculty of visual arts, graduate school of Universitas Sebelas Maret, Solo, Central Java, Indonesia.

A questionnaire was distributed to 100 young designers and 100 design consumers. It was a 5-point Likert scale questionnaire with response options of SA = Strongly Agree, A = AGREE, N = Neutral, D = Disagree, and SD = Strongly Disagree. The questionnaire measured young interior designers' behaviors when entering the design market. It included designers' capital (X1) (proxied by designers' personal identity (X1.1), designers' knowledge (X1.2), and personal branding (X1.3)); designers' strategy (X2) (proxied by consumers' data (X2.1), negotiation (X2.2), and digital marketing (X2.3); and expectation (Y) (proxied by expectation (Y1), need (Y2), and market target improvement (Y3).

In addition to statistical data, semi-structured interviews were also conducted with young designers to find out their behavior in the design market.

The statistical data were analyzed using SPSS 21.0 for Windows. The descriptive analysis result presents the respondents' achievements. Multiple linear regression was done to see the relationship between variables, i.e., between expectation, capital, and strategy. Meanwhile, ordinal logistic regression was also applied to examine the relationship between these two groups of participants in terms of expectation, capital, and strategy.

The interview results were processed using Miles and Huberman's (Miles & Huberman, 1992) analysis method, comprising data reduction, data display, and data verification. Open, axial, and selective coding techniques were applied during the data reduction stage.

Results and Discussion

Respondents Responses

Table 1

Respondents Responses

| Respondents Responses | | | |
|-----------------------|-----------|----------------|----------------|
| Group | Indicator | Percentage | Category |
| Designer | X1.1 | 89.6 | Strongly Agree |
| | X1.2 | 89.6 | Strongly Agree |
| | X1.3 | 73.2 | Agree |
| | | | |
| | X2.1 | 87 | Strongly Agree |
| | X2.2 | 86.8 | Strongly Agree |
| | X2.3 | 88.6 | Strongly Agree |
| | | | |
| | Y1.1 | 94.8 | Strongly Agree |
| Y1.2 | 95.2 | Strongly Agree | |
| Y1.3 | 83.2 | Agree | |
| Design consumer | X1.1 | 89.4 | Strongly Agree |
| | X1.2 | 83.2 | Agree |
| | X1.3 | 78.8 | Agree |
| | | | |
| | X2.1 | 81 | Agree |
| | X2.2 | 65.2 | Do not Know |
| | X2.3 | 91 | Strongly Agree |
| | | | |
| | Y2.1 | 82.6 | Agree |
| Y2.2 | 87.8 | Strongly Agree | |
| Y2.3 | 86.8 | Strongly Agree | |

These responses were then analyzed to find out the relationship between the variables using multiple linear regression test after passing the classical assumption test.

The table of respondents' responses shows that Y1.1 and Y2.1 between designers and consumers are "agree" and "strongly agree".

This indicates that the expectations of market preference could be used as a means to maintain the service quality, given that it is comparable to the portion of consumers looking for designers based on their preference.

Y1.2 and Y2.2 between designers and consumers are "strongly agree".

This indicates that a designer could find out the market needs using a form containing consumers' data, which is important as most consumers prefer designers who know their needs. Y1.3 and Y2.3 between designers and consumers are "agree" and "strongly agree".

This indicates that young designer expect to enhance their market target and will be in line with consumers' expectation who will choose designer effectively.

Regarding X1.1 between designers and consumers are “strongly agree”. This indicates that designers use their backgrounds to sell their designs are in line with the consumers who are looking for a designer based on their background. Then it can be concluded that young designers are able to use their background as capital to enter the design market. The “agree” and “strongly agree” were found in X1.2 between designers and consumers.

This indicates that designers who utilize their design knowledge as the supporting factor of their design marketing are in line with the most consumers that seek for designer based on their knowledge. It can be concluded that young designers are able to use their knowledge as capital to enter the design market. On X1.3 between designers and consumers are “agree”.

This indicates that young designers have personal branding to present the product or service offered are in line with the consumers that seek for designer based on their personal branding. It can be concluded that young designers can build their personal branding as a capital to market their design.

The designer and consumer found “agree” and “strongly agree” on X2.1. This indicates that both sides can communicate appropriately regarding the data needed in the process. The exception is the negotiation (X2.2) indicator where the designer respondents “strongly agree”, while the consumer respondents found the outcome which is “do not know”. X2.3 between designers and consumers were found to “strongly agree”. This indicates that most young designers used digital media to sell their work, matching the fact that most consumers looked for designers through digital media. It can be concluded that digital strategy can be implemented for design marketing.

From this difference, further tests were carried out to further examine the relationship between respondent groups and their respective indicators using multiple linear regression.

Respondents Responses

Table 2

Intervariable relationship of each group

| Intervariable Relationship of each group | | | | |
|--|--------------------|--------------------|------------|------------|
| | Capital * Strategy | Capital | Strategy | Percentage |
| Designer's expectation | Correlates | Does not correlate | Correlates | 48.1% |
| Consumers' expectation | Correlates | Does not correlate | Correlates | 28.6% |

From the results of the multiple linier regression test in Table 2, the relationship of intervariable of each group was found.

The designer participants showed that the designers' capital (X1) and strategy (X2) affect the expectation (Y1), as shown by the data analysis using the F-test showing a sig. value of 0.00. The T-test result showed that the designer's capital (X1) did not affect the designers' expectation (Y) (sig. value of 0.100), while the designers' strategy (X2) affected the designers' expectation (Y1) (Sig. value of 0.000).

The analysis of the coefficient of determination showed that designers' capital (X1) and strategy (X2) affect designers' expectations (Y1). On the other hand, the consumer participant exhibited that information they received (X1) and the designer's strategy (X2) affect consumers' expectations (Y2), as shown by the F-test result showing a sig. value of 0.00. The T-test result showed that the information received by consumers (X1) did not affect their expectation (Y2) (sig. value of 0.52), while designers' strategy (X2) affected designers' expectation (Y) (Sig. value of 0.286). The analysis of the coefficient of determination showed that the information received by consumers (X1) and designers' strategy (X2), and consumers' expectations (Y2) are correlated by 28.6%.

After that, ordinal logistic regression was conducted to examine the relationship between these two groups of participants in terms of X1, X2, and Y variables.

Table 3

Intervariable Relationship of Two Groups

| Intervariable Relationship of Two Groups | | | | |
|--|---------|----------|--------------|------------|
| | Capital | Strategy | Groups Types | Percentage |
| Expectation | 0.211 | 0.00 | 0.013 | 94.5% |

From the results of the ordinal logistic regression test in Table 3, the relationship of intervariable of both groups was found.

The relationship between the designer's capital (X1) and the expectation of both groups (Y) showed a sig.value of 0.211 (>0.05), meaning that partially the designer's capital does not affect the expectation of the two groups of respondents.

The relationship between designer's strategy (X2) and the expectation of both groups (Y) showed a sig.value of 0.00 (<0.05), meaning that partially designer's strategy affects the expectation of both groups.

The relationship between group type and the expectation of both groups (Y) showed a sig.value of 0.013 (<0.05), meaning that partially group type affects the expectation of both groups. By using the ordinal logistic regression test, it can be found that the research variables, namely designer capital, designer strategy, and group type, have an effect on the expectation. The resulting influence is 94.5%.

Discussion

Expectation

Designers have their own beliefs when selling a design, which aligns with their marketing concept. The goal achievement in marketing would highly depend on the market targets' needs and preferences. This is related to market flows that are affected by consumer behavior so designers need to pay more attention to it than their competitors. The creative industry revolves around the fulfillment of consumers' needs, individual preferences, and styles while maintaining the company's profitability along with technological advancement in order to shift consumers' expectations so that consumer satisfaction can be achieved. A number of expectations were noticed, including the expectation of the market's preference, the market's needs, and the expectation of an increased market target.

Expectations of market preference could be used as a means to maintain the service quality, given that it is comparable to the portion of consumers looking for designers based on their preference. There are several ways to identify market preference, among which are communicating directly with consumers, understanding consumers' diverse backgrounds, and having adequate design-related knowledge. The latter may serve as a helpful guideline in presenting a work effectively in the future.

Most young designers have expectations of the future market needs. A designer could find out the market needs using a form containing consumers' data, which is important as most consumers prefer designers who know their needs. Technological development affects the consumers' expectations the creative industry needs to keep up with.

Young designers expect to enhance their market target. They believe they will be able to cover a broader market in the future. Regarding consumers' expectations, this study found that consumers would choose a designer effectively. In addition, changes in consumers' expectations may be affected by technological advancement, thus demanding creative industry keep up with the expectation to maintain their profitability.

This expectation can be managed by considering the designers capital and designers strategy. Once the designer has good knowledge of expectations, a pattern will be formed.

Designer's Capital (information obtained by consumers)

Designers should prepare themselves to be resourceful in the design market as in order to be skilled in the creative industry is examined through his/her readiness. The theory of the element of art highlights the importance of visual messages to serve as the first capital when entering a design market. Among the primary capital, a designer should prepare background, knowledge, and personal branding as a designer.

A designer's background is one of their primary capital, and their experience before or when marketing their design could be an additional skill to compete in the creative industry. In addition to the experience, the field practice also contributes to their readiness to enter the creative industry. Most young designers utilize their backgrounds to sell their designs. This matches consumers who are looking for a designer based on their background. Most consumers look for designers' information before deciding to use their service. This study showed that young designers used their backgrounds as capital to enter the design market.

They utilize their design knowledge as the supporting factor of their design marketing. Their knowledge may include knowledge of style or materials used in the design, among others. The designer needs to have a certain concept to master, and their concepts will likely grow when they look for broader knowledge. This is important, as most consumers look for designers based on their design knowledge. A designer may obtain design knowledge from various sources, including the implementation vendor, previous experience, and trends, among others and it is easier for designers to draw knowledge from digital applications. This study showed that young designers used their knowledge as capital to enter the design market.

Young designers have personal branding to show to develop public perception and exhibit their quality to the public. Designers form this unique identity to present the product or service offered in order to increase consumer satisfaction. This study found that most consumers view a designer based on their personal branding. Designers usually design a portfolio based on personal branding, as a properly presented portfolio would likely draw the market's attention and appreciation to the designer's creativity. Designers' personal branding is established through their environments, service, and presentation media. This study showed that young designers built personal branding as a capital to market their design.

The designer capital mainly made of designers' background, designers' knowledge and designers' branding. All of these designer capitals will have an impact on expectations with the implementation of the right strategy.

Designer's Strategy

This study implemented designers' strategy need to ensure customer satisfaction as a quality designer marketing formula. This formula contains the designers' strength to present their creativity in delivering consumers' preferences and needs.

Designers have three strategies to sell the designs: marketing, communication, and negotiation strategy.

The marketing strategy was used to develop and improve the sale. This strategy may stem from different mindsets between one designer and another. This study found that the marketing strategies used by the young designers were relation and digital media. A relation was found to affect designers' opportunity to obtain consumers but the design business will not develop. In other words, having broad relations should be one of the factors a designer considers.

The use of digital media, including social media, could induce broader responses. Most young designers used digital media to sell their work, matching the fact that most consumers looked for designers through digital media. The market scope is adjusted to the designers' preference. The digital system used by the designer such as Instagram, Youtube, or websites also affects marketing performance by draw consumers' attention when looking for interior design service advertisements. Designer's review about the digital competitors and potential consumer are necessary to show the effectiveness of this strategy. The relationship between consumer interest resulting from using this strategy expand the marketing area and more effective bargaining so the appropriate marketing strategy is obtained.

Young designers in this study also used communication strategies to sell their work. Messages delivered to the public are expected to change public behaviors and attitudes, considering that the delivery and presentation method of a design is one of the skills designers need to have. The first step in their communication strategy was determining the market target. The design was presented directly and persuasively to leave impressions on the market, which provides them with a gap to continue to the next stages. In the second stage, designers communicate their previous works, allowing consumers directly view designers' previous works. This stage may shape a market expectation of the design. After that, the communication continues when consumers provide relevant information to the designers. This information may serve as the communication media of the two parties.

These three communication stages constitute efforts to meet designers' and clients' expectations. In addition to these stages, technological developments also affect this communication followed by the consumer data collection become more effective to obtain the relevant data from the feature digital application. This study showed that young designers used direct communication, work-based communication, and data-based communication to market their designs.

The negotiation strategy was also used to develop and improve the sale. Young designers used this strategy to determine the value given to the market, which potentially draws market attention. Determining the value of the work is not only the responsibility of the individual because the consumers also have the power to influence and compare prices. Negotiation strategy begins by offering a number of services designers could provide. After that, designers and consumers negotiate to find a solution to the problems.

This leads designers to implement several strategies including communication strategies that capitalize on consumer data, marketing strategies that utilize digital media, and negotiation offer strategies.

Relationships among expectation, capital, and strategy

Built upon the primary aim, this study found a relationship between designers' and consumers' expectations, designers' capital, and strategy. As displayed in Table 4, designers' capital and strategy affect their expectations. While designers' strategy was found to affect designers' expectations, designers' capital did not affect designers' expectations. Designers' expectations, capital, and strategy were found to be correlated by 48.1%. This study also noted consumers' expectations, capital, and strategy. Designers' information and strategy were found to affect consumers' expectations. Consumers' expectations were affected by designers' strategy but not designers' capital. Consumers' expectations, capital, and strategy were correlated by 28.6%.

The difference between these two groups was accounted for by the intervening factors. In designers' participant, their expectation was associated with their capital and strategy. Meanwhile, in the consumer participant group, their expectation is associated with designers' information and strategies. To be more specific, a difference was noticed in negotiation strategy. This could arise as the percentage of relationships between variables from designers and consumers are different.

Designers' capital was also found to affect the expectation of both groups of participants. This study found no correlation between information and the type of groups on the group's expectation.

However, strategies and the type of group was found to affect the group's expectation. In other words, the research variables, namely designer capital, designer strategy, and group type, have an effect on expectation by 94.5%.

Conclusions

This study found that young interior designers are demanded to keep up with technological development through innovations to compete in the creative industry. Therefore, young interior designers should prepare themselves before entering the design market. Young designers' preparedness could be viewed from their expectations related to market preference, market needs, and market target improvement.

Designers' capital, which includes background, knowledge, and personal branding, also emerges as one of the foundations an interior designer needs to enter the design market. They also need to set a strategy when entering the design market. The designers' strategies include communication strategies that capitalize on consumer data, marketing strategies that utilize digital media, and negotiation offer strategies. This study shows that expectation, capital, and strategy are interrelated to form designers' behavioral patterns when entering the design market.

This study noticed that young designers' behavior when entering the design market could affect the design consumers. In this regard, young designers need to adjust their behaviors to the consumers' target in order to increase their sales.

This study may serve as a reference for young designers' behaviors when entering the market design. Future studies are recommended to examine the output of design marketing guidelines in order to complement this study. Future studies are also recommended to apply a mixed method study in order to garner more comprehensive, valid, reliable, and objective data.

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Emotional design of traditional Chinese cultural creative products based on user demand

ABSTRACT

Mortice-tenons are the main structural forms of ancient buildings, furniture, and woodwork in China. They are the inheritance of China's craft and cultural spirit, follow the principles of mechanics and have strong practicability. However, mortice-tenons have gradually disappeared from modern life, mainly because they cannot meet the specific needs of users. The purpose of this study is to establish a set of mortice-tenons structure innovation and product design for modern people. By analyzing the types and structural characteristics of mortice-tenon structure, based on the user's needs, using modern creative design methods, and combining with practice, we can verify how to further improve the market acceptance of mortice-tenon structure innovation products, constantly explore the combination of modern technology and material experiments, and explore the emotional design of China traditional cultural creative products. Finally, it is proposed that further research is needed in this field to fully understand the user's behavior of using mortice-tenon structure innovation products, and at the same time, mortice-tenon structure innovation is applied to daily necessities and furniture products to meet the needs of a wider range of user scenarios.

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Introduction

Connotation category and values of traditional Chinese culture

Chinese traditional culture is a kind of national culture that reflects the national characteristics and humanistic features of the evolution and integration of Chinese civilization. Excellent traditional cultural symbols are the treasures of our country. The "craftsman spirit" and "cultural creativity policy" proposed by our country hope that traditional cultural symbol elements can be protected and utilized, and a group of craftsmen who are loyal to traditional culture and committed to inheriting culture can be created (Zhao, 2010). The scope of Chinese traditional culture is very broad.

1. From a historical point of view, Chinese traditional culture, based on the farming culture of the Han nationality, has been formed with the development of history and the continuous absorption of various ethnic groups and different regional cultures on the basis of the culture of the Han nationality. It has rich connotations and forms, and the fusion and cohesion of traditional Chinese culture is the connotation basis of its strong vitality.
2. From the perspective of social structure, Chinese traditional culture is a patriarchal culture based on family. Focus on family, light on individuals, focus on groups, light on individuals. In ancient China, the family system was formed according to the patriarchal relationship, and formed the foundation of the country, providing a social basis for the formation of patriarchal culture.

- From the perspective of social consciousness, Chinese traditional culture is an ethical culture that emphasizes the respect for heaven, the importance of man, and the unity of heaven and man, advocates the accession to the world, and opposes the idea of birth. In Chinese traditional culture, we respect the will of heaven, but pay more attention to ethics, and believe that the principle of heaven and humanity are unified.
- Chinese youth's recognition of the value of Chinese traditional culture, through Chinese cultural creative products, are more likely to obtain "Chinese cultural identity". China is experiencing the background of product consumption upgrading and rapid media transmission. Products with Chinese traditional cultural characteristics that integrate contemporary fashion, oriental aesthetics and craftsman quality are being pursued by more and more young people. "Creative products of Chinese traditional culture" has become a phenomenon of consumer culture, and has affected people's clothing, food, housing, transportation, and use.

The importance of the research on the bucket arch structure and *mortice tenon* structure of Chinese ancient buildings

- The design of ancient Chinese architecture has incorporated the traditional Chinese cultural thoughts, and the ancients have adhered to the idea of the unity of heaven and man. Ancient Chinese architecture is a building system based on wood structure. It has a long history, the largest number, and extremely rich scientific and cultural connotations. It is known as the representative of the Oriental architecture system. The Chinese ancient building system has the seismic effect of elastic frame structure. According to the needs, the change of indoor space, the flexibility of door and window setting, the convenience of construction, maintenance and disassembly, and various roof changes are reasonably arranged.
- Bucket arch is a special art that combines material and spiritual functions. It has a unique style in aesthetics and structure, with ingenious conception and meticulous system, decorative beauty, and formal beauty.
- From the perspective of art or technology, the Dou gong symbolizes and represents the spirit and temperament of Chinese classical architecture. The basic function of bucket arch is load-bearing and anti-seismic. The traditional wooden structure building can stand still, and the bucket arch has played a great role. Bucket arch is a standard component of *mortice-tenon* combination and is the medium of force transmission. The bucket arch holds the

weight of the eaves evenly, plays a role of balance and stability, and is the key to earthquake resistance.

Research Objectives

Study the bucket arch structure in Chinese architecture and the needs of users, conduct analysis, formulate the design guide for bucket arch structure creative products, and design product prototypes.

Through interviews and surveys, the target consumer satisfaction of emotional design creative products of bucket arch structure is studied.

Research Assumptions

In the creative design method of Chinese cultural and creative products based on user needs, the use of emotional design can maximize the satisfaction of target consumers. Based on this, paper analyzes the emotional design of *mortice-tenon* products from the perspective of user needs through literature research and field research, as shown in Figure 1, which is the main research framework of this paper.

Literature Review

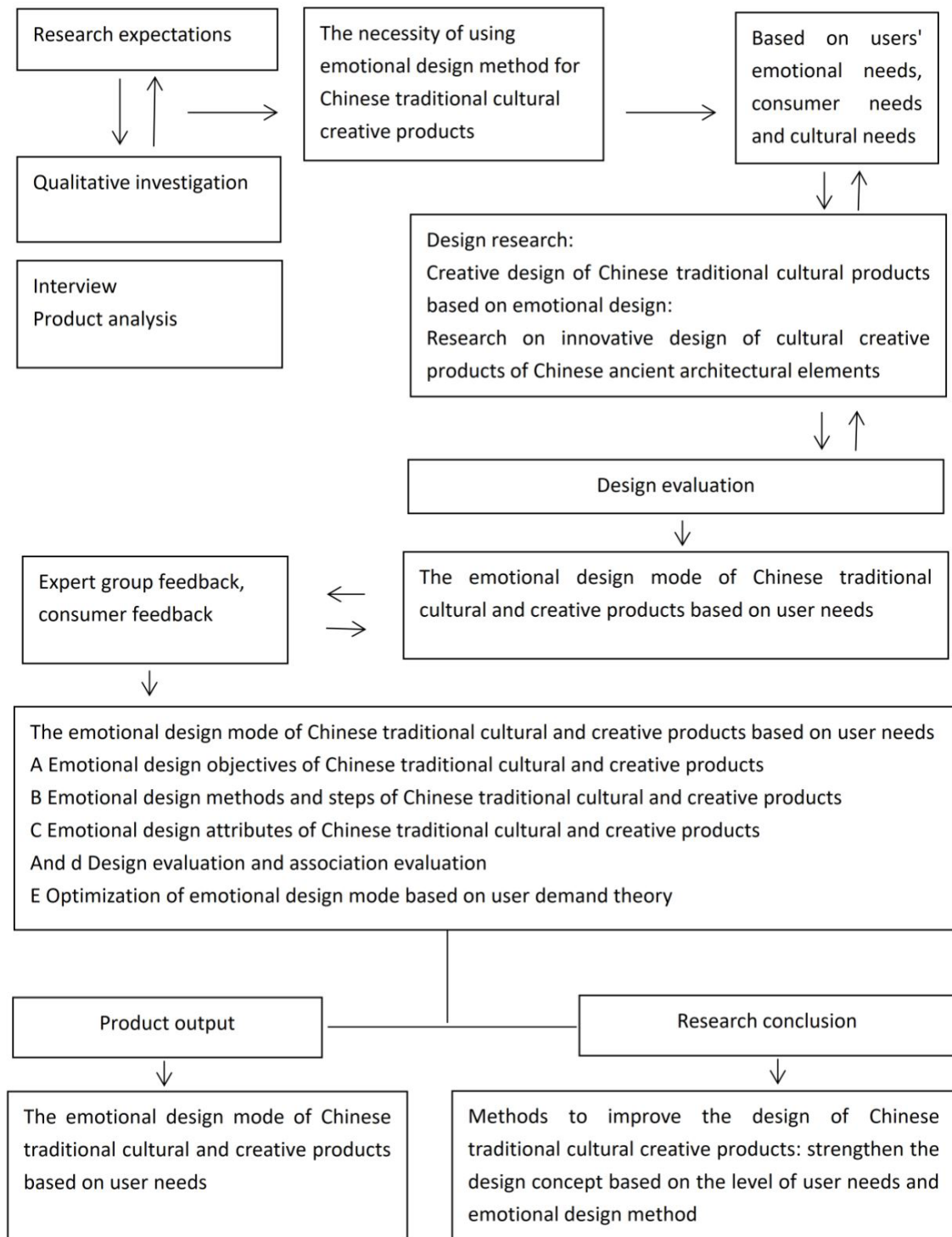
The definition of traditional mortise and tenon in China

In the long history of cultural development in China, *mortice-tenons* first appeared in wooden building structures, such as *mortice-tenon* structures, beams, and beams in ancient buildings, etc.

The building structures connected by *mortice-tenons* are more resilient, which not only has the ability of bearing strong loads, but also allows appropriate deformation, thus having a certain earthquake-resistant effect (Lin et al., 2022).

The *mortice-tenon* structure has also been sublimated and developed in wooden furniture. The *mortice-tenon* structure is recognized as the "soul" of mahogany furniture, especially Ming-style furniture. In short, the *mortice-tenon* structure is the connection mode of engaging and connecting wooden components in the form of concave and convex.

"*Tenon*" refers to the protruding part of the structure, which is also called "*tenon*", and "*mortice*" is the groove of the concave part, which can also be called "*mortice*" or "*mortise*". The way that the two are connected through their own structure and scientific mechanical principles is called "*mortice-tenon*".



» **Figure 1:** Research framework of emotional design of Chinese traditional cultural creative products

There are many ways to classify *mortice-tenon* structures.

If they are divided according to the plane, they can be classified into face-to-face connection, face-to-line connection, face-to-point connection, line-to-line connection, line-to-point connection and point-to-point connection (Guo & Wang, 2018).

There are dozens of tenons such as straight tenon, round tenon, hoop tenon, hook-hanging cushion tenon, pin tenon, hidden tenon, through tenon, tongue-and-groove tenon, running horse tenon, palm tenon, mantis tenon, dovetail joint, buckle tenon, cross tenon, step tenon, shoulder cutting tenon, lattice tenon, wedge tenon, shoulder inserting tenon and so on.



» **Figure 2:** *Chinese traditional building tenon eaves structure*

The concept of cultural and creative products

Culture is the sum of all the social phenomena of the intelligent group and the inherent spirit of the group (Shao, 2019). Cultural and creative products are creative products (referred to as cultural and creative products for short). Through the investigation of the existing market, it is found that most cultural and creative products come from permanent exhibitions such as museums and memorials, and these products are generally active in tourist attractions and museums, so the design of cultural and creative products should pay attention to emotion, "when people buy products, they are actually looking for the feeling, identity and story in the product. And they are actually buying emotion and value identification" (Li & Zhang, 2012).

Which are based on culture, adding, and deleting some parts, and conform to the direction of modern consumption. Through the investigation of the existing market, most of the cultural and creative products come from permanent exhibitions such as museums and memorial halls, and these products are generally active in tourist attractions and museums.

The cultural and creative products in tourist attractions have the characteristics of culture, regionality, practicality and marketability. At first, the sales of domestic cultural creations mainly depended on museums, but with more and more regions attaching importance to cultural industries, cultural and creative products with regional characteristics are also deeply loved by tourists.

China's cultural and creative industries began to sprout with the reform and opening up at the end of the 20th century and were advocated in the development of market economy. At the stage when the government promoted the development of the tertiary industry, cultural and creative industries also began to develop gradually.

The field of product design covers a lot of products. Cultural and creative design is to transform culture into products by means of design, so that cultural value can be visualized. Cultural and creative product is to make an existing physical product, add cultural and artistic features, improve the value of the product itself, and make consumers pay for it, to generate purchasing behavior. Such cultural creative product design can be regarded as a successful case.

The definition of emotional design

Han Feizi said: "Although there is a thousand pieces of jade, to the most expensive and not when, the leak can not hold water." Who is the man to do that?" Even if it is a Baoyu wine vessel, if it leaks and cannot hold wine, it will lose its basic function and have no use value (Wang & Fan, 2016). The same is true of cultural and creative products. A good cultural and creative product should be functional, practical, user-friendly and convenient to meet the material or spiritual needs of consumers in many ways.

Donald Arthur Norman, a famous American cognitive psychologist who once held functionalism and pragmatism, also put forward such a new view in his book *Emotional Design*: whether a product is successful or not, the emotional elements of design may be more critical than the practical elements. Integrating emotion into product design will solve the long-term puzzle of designers, that is, the main contradiction between practicality and vision of products [18]. Emotional design requires designers to take users' emotions and emotions as the starting point of design and take them as the overall development and design ideas. Donald. A. Norman classified emotional elements into three different levels, namely "instinct, behavior and reflection".

The instinctive level is to design from the appearance of the product (Lan, 2019). People's observation and understanding of appearance is the result of their own visual nervous system and brain analysis. If the shape of the product is more in line with the user's own instinctive cognitive feelings, the more likely it is for users to accept and like it. The birth and sale of products are inseparable from the designer's understanding and mobilization of consumers' instinct, so high-quality modeling, color and material will often impress users first.

The behavioral level is to design from the function and use of the product (Deng, Chen & Zhou, 2020). The use of products is a series of human operational behaviors on products. If the high-quality appearance is the first impression, then the operation determines whether the user will continue to use them. The purpose of behavior level is to effectively complete functional tasks and have interesting operation experience on the premise of satisfying users' cognition.

The reflection level starts from the conception and story of the product (Wang & Yang, 2022). It is based on a theme idea, so that every product has a story behind it, creating a scene, and then arousing users' subconscious feelings and needs. Based on meeting the functional needs, we will further meet people's spiritual needs. Through the cultural output of the product itself, users' cognition and recognition of the brand are formed, which makes the product have deep-seated value.

In a word, the key point of emotional design lies in moving and impressing, so that the product can meet certain functionality and create an emotional bond with users, resulting in emotional deduction and thinking.

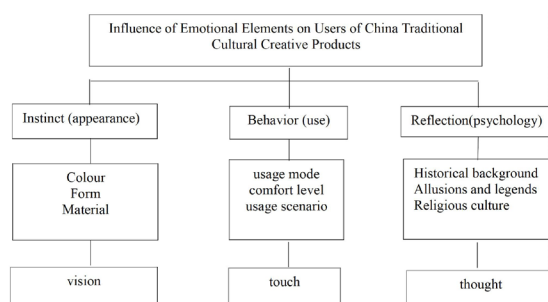
Research on the application of emotional design in product design

Based on the emotional design theory, the three levels of "instinct, behavior and reflection" are regarded as three emotional elements, which correspond to the design of traditional cultural creative products. Starting from the influence of emotional elements on users of traditional cultural creative products, they can be summarized as "appearance, behavior and psychology" (Zhu, Ma & Deng, 2022). Corresponding to the level of human perception interaction, the three influences are subdivided into the level of "vision, touch and thought" of users.

"Vision" refers to the representation design part of traditional cultural creative products, which mainly includes color, shape, and material.

"Touch" refers to the human perception part of traditional cultural and creative products, which mainly includes the user's habitual use, comfort considerations and the judgment of the use scene.

"Thought" refers to the inner feelings and thoughts brought by traditional cultural and creative products to users, which mainly includes historical background, allusions and legends and religious culture. As shown in Figure 3, Cultural and Creative Industry products produce short-term perceptual factors by perceptual stimulation of specific people's vision, touch, and thoughts, which makes users feel emotional about the products.



» **Figure 3:** Influence of emotional elements on users of traditional cultural and creative products in China

The extraction of emotional design elements of China traditional culture starts from three levels:

1. External layer: visual symbols

External image presentation is the most intuitive and commonly used form of expression (Han & Deng, 2022). The external image includes color, modeling, characters, decorative patterns, material texture and other elements.

Giving the most prominent part of the outer layer of culture to the product, such as directly printing local characteristic graphics and patterns on handbooks and canvas bags, the presentation of symbolic elements can quickly convey cultural elements to the main body through the senses, so that consumers can get material satisfaction.

Commonly used design expression methods include material mapping, pattern innovation, three-dimensional plane elements, etc., modern elements and decorative shapes are used more, and cultural elements are more concrete.

2. Middle layer: behavior function

The presentation of cultural behavior process refers to the epitome of a region's long-term lifestyle. It is to deeply understand the skills, functions, operability, convenience of use, safety, combination relationship and other attributes contained in cultural elements and apply them to products.

Usually, it is necessary to recombine with a variety of concrete cultural elements, so that the functions of products can be integrated with the cultural connotations and emotions expressed by behavioral culture. The combination of these skills and creativity makes products more interesting and operational, and consumers can feel the charm of regional culture through participating in the experience.

3. Inner layer: emotional connotation

Emotional connotation is the internal level of culture, including cultural connotation of products, story characteristics of products, emotional characteristics of products and other attributes (Xu & Guo, 2020).

Taking the deepest level of culture as the design point, we use reasonable design techniques to add cultural images, such as cultural legends, ideology, and the concept of praying for blessings, which can resonate with consumers' emotions into the design and creation process, and transform them into products, which convey cultural connotations.

Users can gain associations with regional culture through products, and let users fully understand the rich cultural content of the region.

Research methods and design

Research method

1. Literature research method

Literature research method mainly analyzes the research results of previous scholars, summarizes relevant conclusions, and applies them to existing research. This paper mainly analyzes scholars' information about *mortice-tenon* products and emotional design through literature research, summarizes the theories used in this paper, and lays the theoretical research foundation of this paper.

2. Interview method

Interview method mainly communicates with relevant personnel by means of questionnaire and investigation and obtains the essence of the problem and the strategy to solve it. In this paper, the innovative courtyard lighting design of traditional *mortice-tenon* structural elements in China is the main research object, and field interviews are conducted to analyze the emotional design of *mortice-tenon* products from the user's point of view, and finally constructive suggestions are obtained.

3. Model analysis method

Model analysis mainly refers to a scientific method to realize the prototype by constructing and analyzing research models. This paper mainly uses innovative thinking model to analyze and solve problems.

Research design

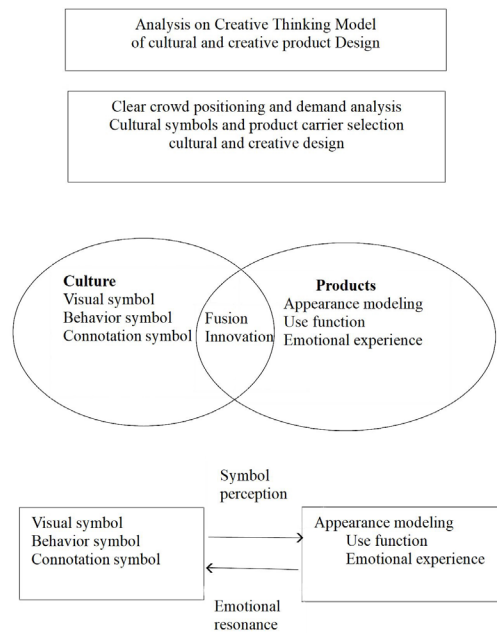
1. Introduction of innovative thinking model of cultural and creative products.

The first point to pay attention to in product design is product positioning. Product positioning is the direction of product design, who is the user of the product, what their use scenarios are, and the main features of the product (that is, selling points, such as functions and emotional attributes). In the design and positioning of products, the choice of target users must be a target consumer group, and special individuals have no reference value. We must have an insight into the common needs of a target consumer group of an order of magnitude, and the development of products will have specific commercial value.

Before product development, you can ask yourself three questions: the first dimension is the target consumer group, which mainly includes target customers, scenarios, channels, prices, and frequency; The second dimension is the product carrier, which mainly includes opportunities, growth points,

functions, materials, processes, and costs; The third dimension is the appeal of product culture.

Based on the three dimensions of culture, such as "visual presentation, use process and emotional appeal", it highlights the innovation of cultural elements such as aesthetics, interaction, experience, and communication. As shown in the figure 4, the innovative thinking model of cultural creative products used in this paper is as follows.



» **Figure 4:** Framework of innovative thinking model for cultural and creative products

2. Expert interviews and user surveys

On the basis of the above model, this paper takes *mortice-tenon* structure cultural creative products as an example to investigate the emotional design of China traditional cultural creative products for users' needs, and the final results are as follows:

First, the basic situation analysis of users.

There are 269 valid data on the mapping data of user demand and emotional design of *mortice-tenon* structural cultural creative products.

As can be seen from Table 1, the proportion of men and women participating in this questionnaire is equal, with the main age ranging from 36 to 45 years old, college education and undergraduate education as the mainstay, and the income is mostly between 5,000 and 10,000 yuan.

It can be seen that grasping the needs of such users is the key to emotional design of *mortice-tenon* structural cultural creative products.

Table 1

Analysis Results of User Basic Information

| Name | Option | Frequency | % |
|-----------------|---------------------------|-----------|--------|
| Gender | Man | 134 | 49.81 |
| | Woman | 135 | 50.19 |
| Age | 25 years old and under | 5 | 1.86 |
| | 26 ~ 35 years old | 49 | 18.22 |
| | 36 ~ 45 years old | 157 | 58.36 |
| | 45 years old and above | 58 | 21.56 |
| Academic degree | High school and below | 36 | 13.38 |
| | Universities and colleges | 108 | 40.15 |
| | Undergraduate course | 95 | 35.32 |
| | Master's degree or above | 30 | 11.15 |
| Income | 3000 yuan and below | 17 | 6.32 |
| | 3,000-5,000 yuan | 80 | 29.74 |
| | 5000-10000 yuan | 135 | 50.19 |
| | 10,000 yuan and above | 37 | 13.76 |
| Total | | 269 | 100.00 |

Secondly, the emotional design of *mortice-tenon* structural cultural creative products is analyzed. Specific to the emotional design, the survey results are as follows:

Table 2 (part 1)

Analysis of specific survey results

| | Average value | Standard deviation | Number of cases |
|---|---------------|--------------------|-----------------|
| You pay attention to the appearance (size, shape, lines) of <i>mortice-tenon</i> structure cultural and creative products. | 3.33 | 0.960 | 269 |
| You pay attention to the color matching of <i>mortice-tenon</i> structure, culture, and creative products. | 3.10 | 0.970 | 269 |
| You pay attention to the diversity of <i>mortice-tenon</i> structure, culture, and creative products. | 3.26 | 0.877 | 269 |
| You pay attention to the traditional cultural patterns of <i>mortice-tenon</i> structural cultural creative products. | 3.10 | 0.989 | 269 |
| You hope that different <i>mortice-tenon</i> structural cultural and creative products can produce different sound effects. | 3.19 | 1.111 | 269 |
| You want the <i>mortice-tenon</i> structure cultural creative products to be silent. | 3.33 | 1.120 | 269 |

Table 2 (part 2)

Analysis of specific survey results

| | Average value | Standard deviation | Number of cases |
|--|---------------|--------------------|-----------------|
| You pay attention to the touch (texture) of <i>mortice-tenon</i> structure, culture, and creative products. | 3.30 | 1.150 | 269 |
| You pay attention to the material of the product. | 3.51 | 1.042 | 269 |
| You want the <i>mortice-tenon</i> structure cultural and creative products to have a soft smell, instead of annoying garbage or plastic smell. | 3.26 | 0.885 | 269 |
| You want <i>mortice-tenon</i> structure cultural and creative products to be able to touch and interact with each other. | 3.66 | 0.860 | 269 |

As can be seen from the above table, you hope that the creative products of *mortice-tenon* structure culture can interact with each other by touch, and the material score of the products you care about is high, which shows that the subjects are more recognized;

You pay attention to the color matching of *mortice-tenon* structural cultural creative products, and you pay attention to the self-realization score of traditional cultural patterns of *mortice-tenon* structural cultural creative products, which shows that the consent of the subjects is weak.

Thirdly, the analysis of the integration and innovation of *mortice-tenon* structural cultural and creative products.

Regarding integrated innovation, our conclusions are shown in Table 3.

As can be seen from the table 3, you hope that the *mortice-tenon* structure cultural creative product has a high practical score, which shows that the subjects are more recognized;

You hope that *mortice-tenon* structure cultural and creative products can be used in cultural and educational activities, but the score is relatively low, indicating that the consent of the subjects is weak.

Fourthly, the analysis of emotional resonance of *mortice-tenon* structure, culture and creative product design. Specific to emotional resonance, the research results obtained in this paper are shown in Table 4.

Table 3

Statistics on Integration and Innovation of Cultural and Creative Products

| | Average value | Standard deviation | Number of cases |
|--|---------------|--------------------|-----------------|
| You want the <i>mortice-tenon</i> structure cultural creative products to be practical. | 3.46 | 1.163 | 269 |
| You want the creative products of <i>mortice-tenon</i> structure culture to be ornamental (such as sculptures, sketches, ornaments, seals, etc.) | 3.29 | 1.111 | 269 |
| You want the <i>mortice-tenon</i> structure cultural and creative products to be large and used in daily life (such as furniture, lamps, space ornaments). | 3.32 | 1.205 | 269 |
| You want the <i>mortice-tenon</i> structure cultural creative products to be small "tools" that can be used. | 3.36 | 0.860 | 269 |
| You hope that the creative products of <i>mortice-tenon</i> structure culture can have commemorative significance. | 3.33 | 0.800 | 269 |
| You hope <i>mortice-tenon</i> structure cultural creative products can be used in social activities. | 3.42 | 0.888 | 269 |
| You hope that <i>mortice-tenon</i> structure cultural and creative products can be used in cultural and educational activities. | 3.23 | 0.741 | 269 |
| You want <i>mortice-tenon</i> structure cultural creative products to be used in your work. | 3.27 | 0.671 | 269 |

Table 4 (part 1)

Statistics of emotional resonance of *mortice-tenon* structural cultural and creative

| | Average value | Standard deviation | Number of cases |
|---|---------------|--------------------|-----------------|
| You hope that the creative products of <i>mortice-tenon</i> structure culture can increase your thinking and identity with traditional culture. | 3.34 | 0.902 | 269 |
| You hope that the <i>mortice-tenon</i> structure cultural creative products can have strong traditional cultural feelings. | 3.36 | 1.037 | 269 |
| You hope that the creative products of <i>mortice-tenon</i> structure culture can help you get out of the negative state. | 3.51 | 1.021 | 269 |

Table 4 (part 1)

Statistics of emotional resonance of *mortice-tenon* structural cultural and creative

| | Average value | Standard deviation | Number of cases |
|---|---------------|--------------------|-----------------|
| You hope that the <i>tenon-mortise</i> structure cultural creative products can make you remember and associate with a certain culture. | 3.28 | 0.811 | 269 |
| You hope that the <i>mortice-tenon</i> structure cultural and creative products can enhance your sense of self-identity. | 3.45 | 0.774 | 269 |
| You hope that the creative products of <i>mortice-tenon</i> structure culture can enhance the social recognition of you. | 3.57 | 0.824 | 269 |
| You hope that the <i>mortice-tenon</i> structure cultural and creative products can enhance your sense of belonging. | 3.30 | 0.676 | 269 |

As can be seen from the above table, you hope that the creative products of *mortice-tenon* structure culture can enhance the social recognition of you, which means that the subjects are more recognized;

You hope that the *mortice-tenon* structure cultural creative products can make you remember and associate with a certain culture, but the score is relatively low, indicating that the subject's consent is weak.

3. Design the research process

Professor Pu Anguo, a famous furniture scholar in Ming and Qing Dynasties, said that it is necessary to study deeply the rules of Chinese furniture shape modeling, structural innovation, mass production demand, material selection, wood color, texture, smell, origin and so on. Modern Chinese furniture has a history of more than 20 years. It is necessary to fully investigate domestic Chinese furniture enterprises, especially those in Jiangnan, Suzhou, and Nan-tong, as well as Shunde and Dongguan in Guangdong, which have their own characteristics in recent years.

Dr. Feng Xianwei, a senior interior designer of China Interior Decoration Association, said, "If you want to have in-depth communication with wood processing plants and furniture manufacturing plants, you must go to the factories to understand the technological process (Figure 5); Taking Suzhou-style garden architecture as an example, how to extract effective expression techniques and form-shaping features from it is conducive to the in-depth development of products. For example, simplify and evolve the traditional furniture structure.



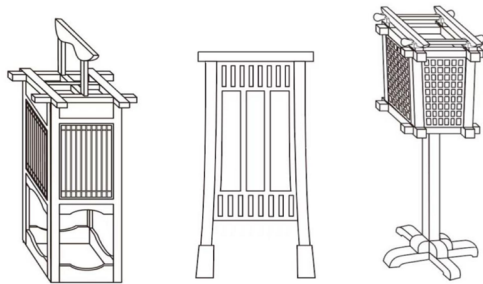
» **Figure 5:** Interview and communication between the author and experts

Extract and abstract some characteristic elements or typical elements. All these have an important impact on the development of this topic.

4. *Design and research process*

Based on the above data analysis and results, we can see that the design of cultural and creative products based on user needs should consider the income of the middle humanities, product practicability, social recognition, and other aspects. First of all, attention should be paid to the design rationality in the process of the first stage design demonstration.

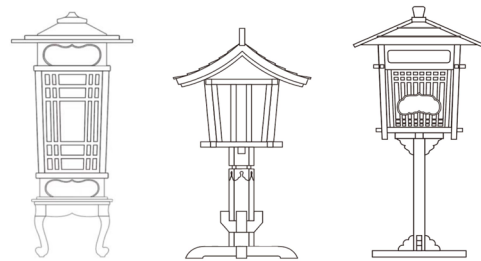
As shown in Figure 6, a detailed analysis of the product's characteristics should be performed prior to the design. Including: 1. Easy to assemble, carry; 2. Indoor and outdoor multi-scene application; 3. Diversified combination styles to meet different needs.



» **Figure 6:** Sketch of mortice-tenon structure innovative luminaire products

Secondly, the second stage of the design study is to deepen the design according to the opinions of experts. As shown in Figure 7, the cultural creative products of deepening mortice-tenon structure have the following characteristics: 1. & 2. Design outdoor lamps for the courtyard scene; 3. Diversified combination styles to meet different needs.

Based on this, combined with expert advice, we should pay attention to the practical design, cultural principles. To increase the structure of the roof of the ancient building.



» **Figure 7:** Design sketch of mortice-tenon innovative garden lamps in the second stage

Finally, the third stage chooses a product for further study according to expert advice and user survey. As shown in Figure 8, after analyzing the specific situation of the product characteristics, we can see: 1. Open the roof and replace the internal light source; 2. & 3. easy to operate, the hexagonal structure of the base is very strong; You can choose from a variety of light sources, either rechargeable or plug-in. Because the design carrier of garden lamps is the main one at this stage, the product can continue to be transformed according to the same parts in the later stage. This will be more conducive to the use and choice of consumers, can be transformed according to different uses; In addition, the appearance of spraying can also be customized, according to the needs of consumers spraying, this will be more modern, strengthen the role of emotional design method.

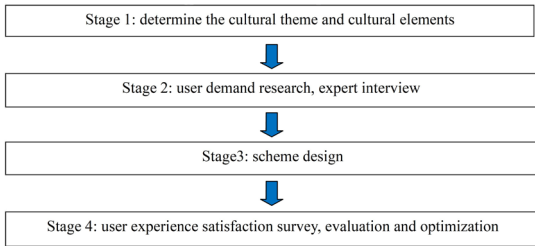
Design conclusion

Emotional design process of Chinese cultural creative products

The emotional design of Chinese cultural creative products is to combine the emotional needs of users in household products and express the emotional information of users in the design stage. Therefore, in the whole process of the application, we should pay attention to the collection of users' emotional information and the integration of emotional design.



» **Figure 8:** Final design of garden mortice-tenon innovative luminaire design



» **Figure 9:** The emotional design process of lighting products based on Chinese traditional culture

As shown in the figure above, the process of emotional design of lighting products based on Chinese traditional culture is divided into four stages: cultural theme determination, user experience research, program design, evaluation, and optimization. Choose a perspective from the traditional culture for in-depth theoretical research, so that the ideas conveyed can be in line with modern

aesthetic orientation and values. After determining the design theme, the target users are surveyed and interviewed to understand the users' inner functional and emotional needs for lighting products.

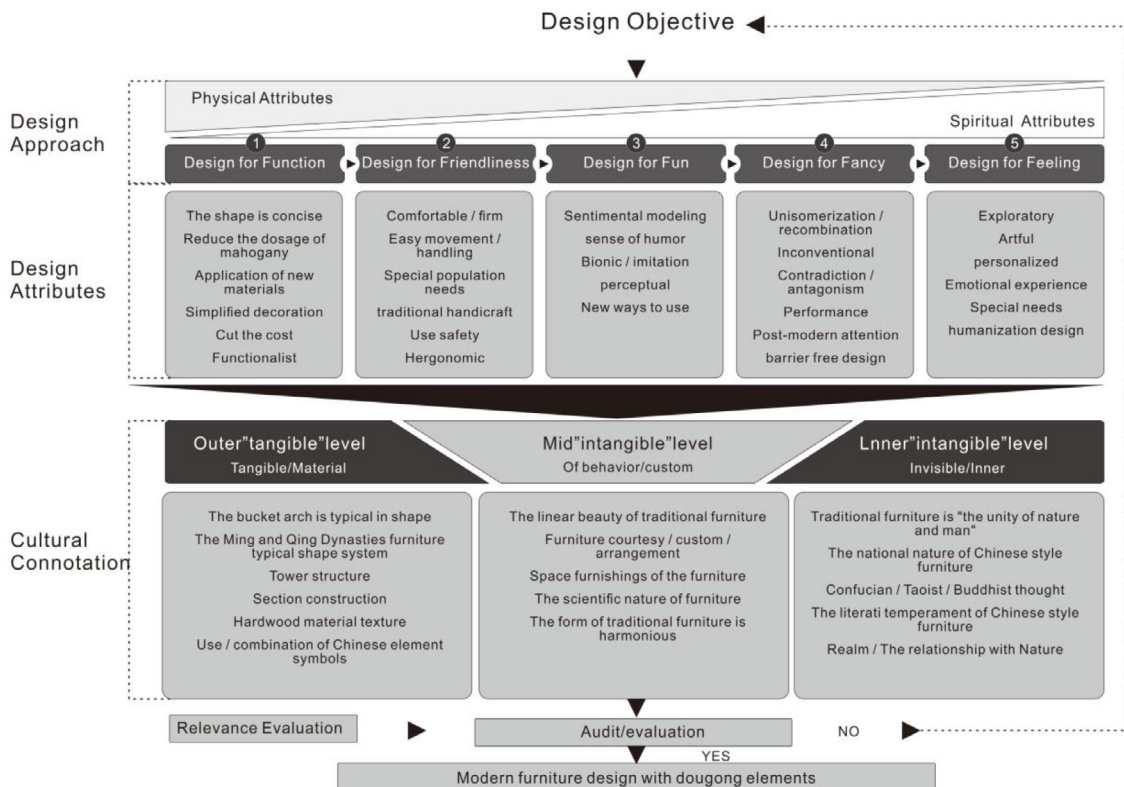
Through brainstorming and many sketches, the innovative design of emotional household lighting is carried out.

Starting from the aspects of shape, function, and cultural connotation, we designed a lamp product that is both interesting and does not lose cultural connotation, so as to bring users a new emotional interaction experience and cause users to identify with traditional Chinese culture. In addition, to bring better experience to users and make the product more perfect, initial interviews are still selected to evaluate the experience of the product to target users after the initial plan is completed.

According to the evaluation results, the poor user experience should be further improved and perfected.

Principles of emotional design of Chinese cultural creative products

1. The principle of rationality
2. The principle of creativity
3. The principle of culture
4. Economic principles



» **Figure 10:** Emotional thinking of China traditional cultural creative products based on hierarchy of needs theory

Emotional design model of traditional Chinese cultural creative products based on hierarchy of needs theory

After studying the emotional design of traditional Chinese cultural creative products based on user needs, the author summarizes the emotional design model of traditional Chinese cultural creative products based on the hierarchy of needs theory. The design conclusion of this paper is shown in the figure 9.

Conclusion

This paper studies its innovative design path in modern cultural and creative products, reconstructs device design, develops functional mortise and tenon and tenon products, and outputs mortise and tenon and tenon cultural connotations to the outside world. Based on maintaining the traditional wisdom of mortise and tenon structure, emotional design method can be used to open new ideas for the design of modern cultural products in China.

The application of *mortice-tenon* structure in the design of cultural and creative products mentioned in this paper only provides a feasible scheme for the design of cultural and creative products in the future. Of course, there are more possibilities to be discussed. It is hoped that this study can contribute to the development of traditional Chinese cultural and creative products. In 2023, there will be many new situations and more new possibilities for cultural and creative design.

The author hopes that through this way, China's traditional culture and traditional craft can have new market and new vitality. In the future, we will continue to search for the innovation points of *mortice-tenon* joints, combine them with modern times, put inheritance and innovative development into the primary consideration, and make *mortice-tenon* joints skills show their unique advantages in the development of modern society.

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QR code design: From digital graphics to environmental, product and fashion design

ABSTRACT

Classification of design codes by the level of complexity of their design was created for the first time. The obtained results are key to understanding the role of the QR code as a full-fledged work of art in the context of modern design. In the future, this will allow us to single out the most noticeable trends in the development of coded information in the conditions of modern visual culture.

KEY WORDS

Broadband, graphic design, barcode, QR code, artistic image, design approach, artistic and visual solution, advertising, digital design

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Introduction

The life of a modern person cannot be imagined without visual data. In the 21st century, QR codes as objects with the possibility of multimedia and imaginative transformation began to be actively used by designers and used in various spheres of human life (Xu et al., 2019). Companies place them on billboards to make quick sales online, on food and beverages, on movie posters or educational videos, on store windows, and on advertising signs. QR codes are very often placed near exhibits, people use them on business cards, bracelets, in the form of a pendant on a chain. In the city, you can find codes that are navigators that help you navigate the environment (Sklyarenko & Kalytyuk, 2020).

The development of QR code is based not only on the software and mathematical component, but

also on the artistic and figurative component, which implies positioning the code as an artistic means for expressing the author's artistic idea (Vorobchuk & Pashkevych, 2022). Despite the fact that QR codes have a functional purpose in the queue, very often they become an artistic or design work.

The goal is to study modern designer QR codes and, based on their analysis, offer a classification of encoded information according to the level of complexity of their design, as well as provide a characteristic of each of the types.

Formulation of the problem

Over the past decades, there has been a tendency for a gradual transition from contemplating a work

of art to the viewer's participation in it. For example, the viewer can use a QR code to get additional information about the history of creating a work, the author, the production technique, watch a video, and so on (Sklyarenko & Kalytyuk, 2020).

Visualization technologies are rapidly improving, so despite the existence of various concepts, it can be argued that today the theoretical and practical issues of QR code development by designers require additional research.

Xu et al. (2019) found that with the proliferation of smart mobile devices, QR code has become one of the most commonly used types of two-dimensional code in the world (Xu et al., 2019).

A number of methods have been developed to visually embellish the appearance of QR codes. Sometimes when creating designer code, its practical significance is lost.

Researchers Tsukanova & Dibrova (2013) refer to a QR code as a direct response carrier. They investigated the advantages and disadvantages and showed examples of the implementation of QR codes in the modern realities of Ukrainian business, but did not focus on the aesthetic appearance of the code (Tsukanova & Dibrova, 2013).

Gültekin, Ural & Yaman (2019) made several parts with QR codes, they printed cubes and compiled a matrix code (Gültekin, Ural & Yaman, 2019). Instead Deineko, Kraievska & Lyashenko (2022) in their article consider such QR codes that stand out significantly against the background of the same type of QR codes and focus on the importance of an attractive appearance of the code as an advertising element (Deineko, Kraievska & Lyashenko, 2022). For example, painting matrix codes in the company's corporate colors or embedding a logo in the code.

Researchers Karrach, Pivarčiová & Božek (2020) considered various ways to transform matrix codes (Karrach, Pivarčiová & Božek, 2020). They described that the QR code structure restricts its change. This study opens up more opportunities for graphic designers when creating designer code.

In their article, Abu-Jassar et al. (2021) analyze the features of the structure of image recognition methods based on which matrix codes are decoded (Abu-Jassar et al., 2021). This makes it possible to develop a designer QR code while maintaining its main function — decoration.

People scan QR codes and usually trust their contents, but there is no standard mechanism for ensuring code privacy. Scientists Huang, Chang & Li (2022) investigated that QR codes are transmitted

through public channels (Huang, Chang & Li, 2022). To prevent fraudsters in the decoding procedure, a scheme was proposed that would be efficient and highly secure and ensure the security of the device.

In their study Focardi, Luccio & Wahsheh (2019) conducted tests showing that the usability and appearance of matrix codes affects the performance of QR code scanning (Focardi, Luccio & Wahsheh, 2019). As a result, the consumer evaluates the attractive appearance of the code without neglecting cyber security, so they choose an aesthetic QR code that is safe for their decoding device.

Broadband in design is mainly considered from a software point of view, but since the artistic and figurative aspects of design shaping are common to the design of all design objects, regardless of their functional purpose, these publications do not lose their relevance.

The relevance of the research is due to the need to develop a design code and use encoded information in the modern design of various objects.

Methods

Main research method is an artistic and imaginative analysis of the issue under study. It involves a thorough study of the visual system of the work of art in order to identify the artistic concept of the work, the idea laid down by the designer for a logical and consistent analysis of the image, also method of grouping information, which are used in the formation of the table.

Study uses artistic-figurative and structural approaches. The authors apply comparative analysis, which involves the search and identification of similarities or differences of the same type of properties of the studied object as one of the tools of the art history method. In research used visual methods of cognition, which involve the use of demonstrations and illustrations which are extremely relevant today.

Samples of objects, selected as examples, were taken from the official websites of designers or design studios that developed them.

Problem Development

In this paper, we explore a new interpretation of the representation of QR codes in the form of structures embedded in arbitrary shapes. The study uses artistic and imaginative analysis, because each design code is developed in accordance with the field of activity in which it will be used. Thus, designer QR codes are original, durable and reliable (they are harder to crack and reproduce).

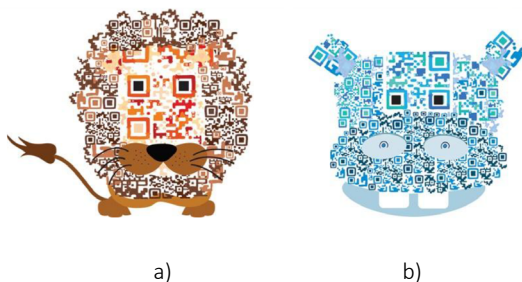
Although QR codes are made as decoration, they can be embedded to spread information due to their realistic and reliable operation. Each QR code, whether online or in print, can simply be decoded using your mobile phone's camera.

Matrix codes are used to promote new exhibitions, in student art portfolios, on business cards, on museum websites and exhibits, and so on. QR code is easy to integrate into illustrations, logos and any artistic material.

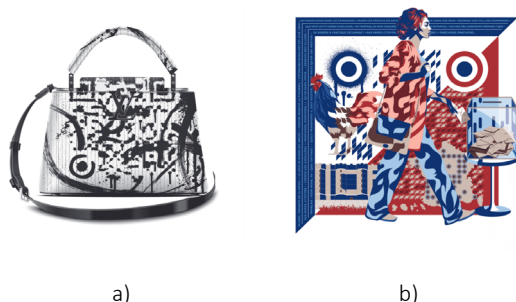
The novelty is that artistic QR codes are not only black and white, but also colored, made of different shapes and materials.

QR code is a technological achievement, but graphic designers create a work of art that includes a mathematical-software and artistic-figurative component.

Able to meet the needs of many professional sectors, the QR code allows you to get direct access to information after scanning. For example, food packaging contains information about the nutritional value of a dish or drink (Fig. 1) (Mouzouris, 2022). A QR code integrated on the packaging of a cosmetic product transmits its composition. The matrix code invites users to visit the store, indicating the route to go to the displays (Fig. 2:a) (The Art of QR Codes, 2022).



» **Figure 1:** Artistic QR code, Irene Mouzouris, London, United Kingdom, 2020 (Mouzouris, 2022)



» **Figure 2:** Designer QR code, The ART of QR Codes (a) fashion brand Destination, New York, USA, 2022; (b) fashion brand Destination, New York, USA, 2021 (The Art of QR Codes, 2022)

Designer QR codes can also be collectibles, adding informative value to everyday items that are usually discarded (Fig. 2:b) (The Art of QR Codes, 2022).

Some graphic designers modify the code by animating it. Designers use specialized software to create animated graphics in social networks. Thus, the Chinese company Art memoe animates codes for companies such as Rong Chuang and Adobe (Fig. 3) (Minor, 2022).



» **Figure 3:** Animated QR code, Art memoe (a) Rong Chuang QR Code Design, China, 2020; (b) Adobe QR Code Design, China, 2020 (Minor, 2022)

Designer codes quickly penetrate every person's daily life. Designer Thorunn Arnadottir decorated Swarovski crystals with QR codes to make Swarovski crystals recognizable. Also, Thorunn Arnadottir designed a "Super self-promotional dress" for Icelandic pop star Kali from Steed Lord. After scanning the QR code, the viewer goes to a number of links, which includes videos of the group, music sites (Fig. 4) (Thorunn, 2022).

A seasonal code that can be decoded in warm seasons has been created for the landscape agency Landscape Studio's (Fig. 5) (Campbell, 2022). This method of self-presentation added several dozen clients to the landscape agency.

Another example of a temporary QR code was created by English photographer David Sykes. He decided to use it to promote his own new website by sending invitations to his friends in the form of a QR code model made of shoes, calculators, briefcases, tape recorders, etc. (Fig. 6) (Zhang, 2011).

Architect Alt S. created a unique mural in the city of Siracusa in Italy (collabcubed, 2012). The image is a mosaic consisting of dozens of unique QR code fragments, each of which is associated with the organization of contemporary art in the city (Fig. 7) (collabcubed, 2012).

QR code is a versatile and flexible tool. The advertising agency DDB has developed portraits of artists that consist of many small QR codes (Fig. 8) (Agency: DDB, 2022). This ad, titled "Michela, Mike, Paul", was published in the United Arab Emirates and created for the MusicMaster brand.

Samples of designer QR codes, that can be decoded under illumination only, were discovered during the artistic analysis. For example, the project of architect Drzach and programmer Suchy "Shadow Cloud" is presented in the form of a cube that creates shadows forming a QR code (Fig. 9) (Watkin, 2017). A similar idea was previously presented by Triada Studio Games in the virtual puzzle

Shadowmatic (Fig. 10) (Brown, 2000).

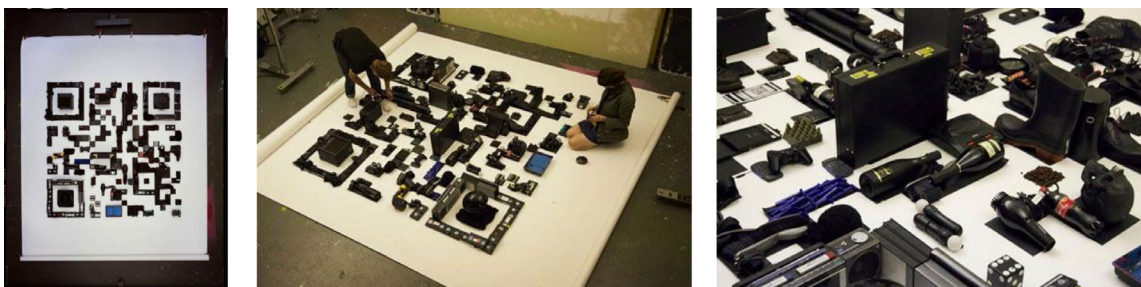
After analyzing samples of design codes, it was found that today in design, a QR code allows you to expand the boundaries of communication between the object and the viewer. The viewer can use the QR code to find out additional information about a particular work or object.



» **Figure 4:** Coded patterns in this beaded dress "Super self-promotional dress", Thorunn Arnadottir, London, United Kingdom, 2017 (Thorunn, 2022)



» **Figure 5:** Landscape Studio's QR Code Garden, Chelsea, United Kingdom, 2017 (Campbell, 2022)



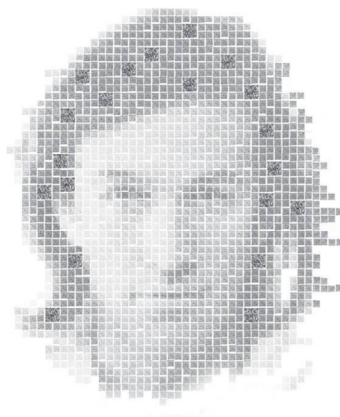
» **Figure 6:** QR Code Made from Ordinary Objects, David Sykes, London, United Kingdom, 2018 (Zhang, 2011)



» **Figure 7:** City project, by Alt S., Siracusa, Sicilia, Italy 2012 (collabcubed, 2012)

I AM MY MUSIC. I AM **musicmaster**

Discover the music that defines me. Snap the QR codes in my portrait with your smartphone and download the twenty tunes for free. As the region's most comprehensive download site, Music Master allows you to explore and express your individuality through your favourite tracks.



a)



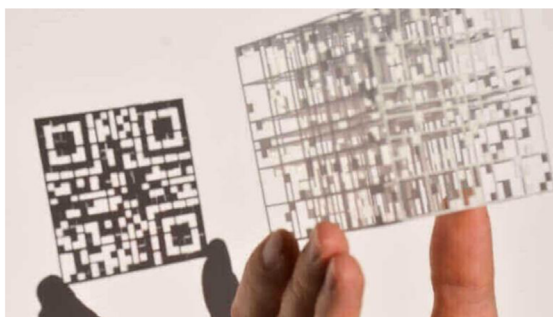
I AM MY MUSIC. I AM **musicmaster**

Discover the music that defines who I am. Snap the QR code on your smartphone and download all my top twenty tracks for free.

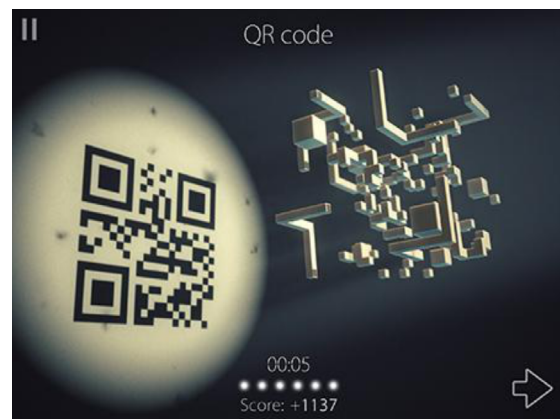
As the region's most comprehensive music download site, Music Master lets you explore your individuality through your own tunes.

b)

» **Figure 8:** MusicMaster, agency: DDB:
 (a) Paul, Dubai, UAE, 2020;
 (b) Michela, Dubai, UAE, 2020 (Agency: DDB, 2022)



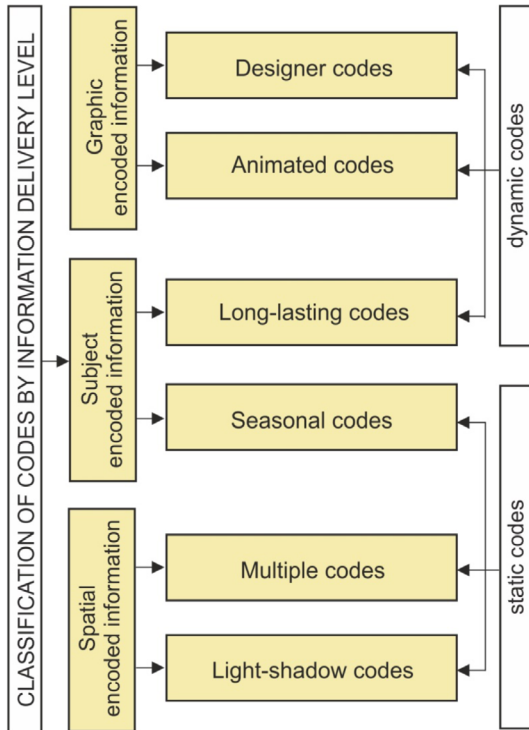
» **Figure 9:** Shadow Cloud, Technoram, Artists Drzach and Suchy Create, Switzerland, 2019 (Watkin, 2017)



» **Figure 10:** Shadowmatic, Triada Studio Games, Yerevan, Republic of Armenia, 2017 (Brown, 2000)

Results

The result of the study is the following classification of codes according to the level of complexity of their design (Fig. 11).



» **Figure 11:** *Classification of codes by information delivery level*

In this case, we identified simple, complex and super-complex codes that are currently developed by graphic designers. This gave grounds for dividing them into three groups: graphic, subject, and spatial encoded information.

Graphic encoded information contains designer (Fig. 1-2) and animated codes (Fig. 3). Subject encoded information allows the designer to create long-lasting codes (Fig. 4) and seasonal codes that, for example, depend on the time of year or other environmental conditions (Fig. 5-6). Spatial encoded information shows the complexity of designing light-shadow codes (Fig. 9-10) and multiple codes (Fig. 7-8).

QR codes that are considered by the creation tool are dynamic and static (Fig. 11). Dynamic codes allow you to change the hosted information that the consumer receives during decoding, while static codes store only the primary data. For graphic designers, this is an essential indicator when designing designer code.

So, the presented classification within the framework of artistic and figurative analysis combines design solu-

tions, the common characteristic features of which are revealed after a detailed analysis of structural and figurative characteristics, which makes it possible to consider QR codes as an innovative tool for design. The obtained results are key to understanding the role of the QR code as a full-fledged work of art in the context of modern design. In the future, this will allow us to single out the most noticeable trends in the development of coded information in the conditions of modern visual culture.

Conclusion

The conducted research shows that today in the practice of design, a clear trend of growing popularity of conceptual design objects, the change of which requires direct interaction with the consumer, has formed. It becomes a central part of the transformation process, influencing the final result.

As a result of the analysis of modern QR codes, a classification of codes by the level of complexity of information submission was proposed. Three types of coded information are defined: graphic (designer, animated code), subject (long-lasting, seasonal code), spatial (light-shadow and multiple codes). Based on a specific examples, the characteristic features of design solutions of QR codes are considered. It has been established that artistic analysis expands the limits of perception of encoded information. It was determined that earlier QR-codes were perceived as auxiliary functionality and were used individually, but now they are present in many areas of project activities of design and art.

Positioning code as an artistic medium for expressing a designer's artistic intent gives designers more opportunities to implement new concepts and viewers - new ways to interpret. Today, QR-codes are not only software-mathematical objects, but also artistic-figurative ones, therefore, they can be considered works of modern art, which makes them a valuable asset of modern times and an interesting object of research.

The possibility of direct interaction of the viewer with the design code allows the viewer to become an active participant in decoding the QR code and receive various emotions. In the future, it is planned to investigate the role and place of designer encoded information in the conditions of modern visual culture.

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